ADA

EVALUATIONS OF QMI AFTER-MARKET ADDITIVES

INTERIM REPORT
TFLRF No. 382

by

Edwin A. Frame

U.S. Army TARDEC Fuels and Lubricants Research Facility
Southwest Research Institute® (SwRI®)
San Antonio, TX

for

U.S. Army TARDEC
Petroleum and Water Business Area
Warren, MI

Contract No. DAAE-07-99-C-L053 (WD36)
SwRI Project No. 03.03227.36

February 2007

Disclaimers

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

Trade names cited in this report do not constitute an official endorsement or approval of the use of such commercial hardware or software.

DTIC Availability Notice

Qualified requestors may obtain copies of this report from the Defense Technical Information Center (DTIC), Attn: DTIC-OCC, 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, Virginia 22060-6218.

Disposition Instructions

Destroy this report when no longer needed. Do not return it to the originator.

EVALUATIONS OF QMI AFTER-MARKET ADDITIVES

INTERIM REPORT
TFLRF No. 382

by

Edwin A. Frame

U.S. Army TARDEC Fuels and Lubricants Research Facility
Southwest Research Institute® (SwRI®)
San Antonio, TX

for

U.S. Army TARDEC
Petroleum and Water Business Area
Warren, MI

Contract No. DAAE-07-99-C-L053 (WD36)

Approved for public release: distribution unlimited

February 2007

Approved by:

Edwin C. Owens, Director
U.S. Army TARDEC Fuels and Lubricants
Research Facility (SwRI®)

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	March 2006	Interim, September 2005 – December 2006

4. TITLE AND SUBTITLE
Evaluations of QMI After-Market Additives

5. FUNDING NUMBERS
DAAE-07-99-C-L-053
WD 36

6. AUTHOR(S)
Frame, E.A.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army TARDEC Fuels and Lubricants Research Facility (SwRI)
Southwest Research Institute
P.O. Drawer 28510
San Antonio, Texas 78228-0510

8. PERFORMING ORGANIZATION REPORT NUMBER
TFLRF No. 382

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army RDECOM
U.S. Army TARDEC
Petroleum and Water Business Area
Warren, MI 48397-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
Three types of QMI after-market additives were evaluated to determine their effects on the properties of military products. The additives were (1) a fuel additive, (2) an engine oil additive, and (3) a gear oil additive. The major adverse effects observed were that the QMI engine oil additive reduced the viscosity of Military engine oil, and reduced the Flash Point. Low temperature properties of the engine oil were slightly improved. The QMI gear oil additive produced the following adverse effects: decreased the Flash Point of the gear oil and increased low temperature viscosity and foaming characteristics. The QMI fuel additive was blended in JP-8 with the following adverse effects: reduced Cetane Number, and reduced water separation tendencies. Fuel lubricity was improved for ground vehicle applications, and a slight improvement (<2%) in fuel economy was measured with the additive in JP-8. PM and NOx exhaust emissions from a diesel engine were unchanged with the QMI fuel additive present. Finally, with the QMI fuel additive present, diesel engine piston deposits were increased in the Caterpillar (Cat) 1K/1N test.

14. SUBJECT TERMS

Fuel	JP-8	Gear oil
Diesel fuel	After-market additive	Engine Oil
Piston deposits	Cat 1K/1N	Fuel economy
Exhaust emissions		

15. NUMBER OF PAGES
110

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

EXECUTIVE SUMMARY

Three types of QMI after-market additives were evaluated to determine their effects on the properties of military products. According to the "Department of Defense Policy Guidelines for Use of After-Market Fuel and Lubricant Additives" [1]:

1. The additive must provide a measurable level of improvement over that of the finished fuel or lubricant product being evaluated.

2. The additive must not create any adverse side effects when added to a finished fuel or lubricant product.

The QMI additives were (1) a fuel additive, (2) an engine oil additive, and (3) a gear oil additive. Each of the QMI additives produced unacceptable side effects. The QMI fuel additive reduced cetane number and the water separation capability of the fuel. There was an increase in diesel engine piston deposits in the Caterpillar 1K/1N test. The fuel additive did provide a slight (<2%) improvement in fuel economy and improved fuel lubricity properties for ground vehicle applications. The QMI oil additive produced the following adverse effects: reduced Flash Point and reduced the viscosity of Military engine oil. Low temperature properties of the engine oil were slightly improved. The QMI gear oil additive produced the following adverse effects: decreased the Flash Point of the gear oil and increased low temperature viscosity and foaming characteristics.

FOREWORD/ACKNOWLEDGMENTS

The U.S. Army TARDEC Fuels and Lubricants Research Facility (TFLRF) located at Southwest Research Institute (SwRI), San Antonio, Texas, performed this work during the period September 2005 through March 2006 under Contract No. DAAE-07-99-C-L053. The U.S. Army Tank-Automotive RD&E Center, Petroleum and Water Business Area, Warren, Michigan administered the project. Mr. Luis Villahermosa (AMSTA-RBFF) served as the TARDEC contracting officer's technical representative.

The author would like to acknowledge the contribution of the TFLRF technical support staff along with the administrative and report-processing support provided by Linda De Salme and Rebecca Emmot.

The project was conducted for U.S. Naval Surface Warfare Center—Carderock Division (NSWCCD) as per a request from the U.S. Marine Corps Systems Command (MARCORSYSCOM).

TABLE OF CONTENTS

Section **Page**

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

ACRONYMS AND ABBREVIATIONS

%	Percent
Δ	Delta
°C	Degrees centigrade
°F	Degrees Fahrenheit
@	at
AO	Antioxidant
ASTM	American Society for Testing and Materials
bhp	Brake horsepower
BSOC	Brake specific oil consumption
C.L.	Confidence limits
CAT	Caterpillar
CI/LI	Corrosion Inhibitor and Lubricity Improver
CO	Carbon monoxide
COV	Coefficient of variance
cp	Centipoise
CRC	Coordinating Research Council
cSt	Centistokes
DOD	Department of Defense
EOTOC	End of test oil consumption
FBL	Final boiling point
FSII	Fuel System Icing Inhibitor
FTM	Federal Test Method
FTP	Federal Test Procedure
g/kw-h	Grams per kilowatt-hour
g/mi	Grams per mile
GFM	Government furnished equipment
HFRR	High-frequency reciprocating rig
Hr	Hour
HwFET	Highway Fuel Economy Test
IBP	Initial boiling point
JFTOT	Jet Fuel Thermal Oxidation Tester
L	Liter
MARCORSYSCOM	U.S. Marine Corps Systems Command
Max	Maximum
MDA	Metal deactivater additive
mg	Milligram
mg/l	Milligrams per liter
mgKOH/g	Milligrams potassium hydroxide per gram of sample
MJ/Kg	Megajoules per kilogram
ml	Milliliter
mm	Millimeter
mmHG	Millimeters of mercury
mpg	Miles per gallon
MSEP	Micro-Separometer

ACRONYMS AND ABBREVIATIONS (CONTINUED)

NOx	Oxides of nitrogen
NR	Not required
NSWCCD	U.S. Naval Surface Warfare Center – Carderock Division
NYS	No yield stress
oz	Ounce
pS/m	pico Siemens per meter
Pa	Pascuals
PM	Particulate matter
ppm	Parts per million
PTFE	Teflon
RPM	Revolutions per minute
SLBOCLE	Scuffing load ball on cylinder lubricity evaluator
STDEV	Standard deviation
SwRI	Southwest Research Institute
TFLRF	U.S. Army TARDEC Fuels and Lubricants Research Facility
TGF	Top groove fill
THC	Total hydrocarbons
TLHC	Top land heavy carbon
WDR/WDN	Weighted deposit rating for Caterpillar engine tests
JP-8 + 100	JP-8 kerosene turbine fuel which contains thermal stability improver additive

1.0 BACKGROUND AND OBJECTIVE

The U.S. Army TARDEC Fuels and Lubricants Research Facility (TFLRF) performed selected tests to evaluate QMI after-market additives for diesel fuel, engine oil, and gear lubricant. TFLRF performed the evaluation for the Naval Surface Warfare Center—Carderock Division (NSWCCD) as per a request from the U.S. Marine Corps Systems Command (MARCORSYSCOM). The analyses conducted were those specified in the "Department of Defense Policy Guidelines for Use of After-Market Fuel & Lubricant Additives" [1] dated July 1996. Because the U.S. Army uses JP-8 fuel as the primary fuel for ground vehicles, the QMI Fuel Additive was evaluated in JP-8, and changes to the JP-8 fuel versus specification requirements were determined. In addition, several diesel fuel properties considered to be important were also determined. The fuel analyses, as detailed in section 2.0, were substituted for the fuel tests listed in the DOD guide because the fuel additive was evaluated in the fuel used by Army ground equipment (JP-8). The Navy also wanted to determine fuel additive effect on water separation of the fuel, as this is a key Navy fuel property; thus, water separation by ASTM D 1401 test was included. Other tests, such as fuel lubricity by ASTM D 6078 and D 6079, were included because fuel lubricity is a key property for successful operation of ground vehicles.

The engine oil additive was evaluated in SAE 15W40 grade MIL-PRF-2104G engine oil because this grade is most widely used by the Army. ASTM D 6922 was used for stability and compatibility and storage stability because this method is the latest available. The gear oil properties were all conducted in accordance with the DOD guideline document [1].

According to the after-market additives guidelines [1]:

> "For acceptance, a candidate must meet the following specific goals:
>
> 1. The aftermarket additive package **must provide a measurable level of improvement** over that of the finished fuel or lubricant product being evaluated. This improvement must result in, but is not limited to such factors as, reduced fuel consumption, improved engine performance, reduced engine emissions, reduced wear, decreased overall engine and powertrain maintenance, and reduced corrosion.
>
> 2. The aftermarket additive **must not create any adverse side effects** when added to a finished fuel or lubricant product. These side effects are produced by incompatibility of the added ingredients with the additives used in the finished products, their potential anti-synergistic effects, non-miscibility and/or incompatibility, or any anticipated chemical reactions of these materials. Examples of adverse side effects are water emulsification, deposit formation in critical piston and engine areas, marginal fuel filtration, sludge formation, excessive wear, increased corrosion, increased emissions, or loss of additive response/effectiveness.
>
> If the results of these "screening tests" support the claims, the sponsoring organization will conduct additional systems-oriented evaluations as needed on the candidate additive(s), and a purchase description/specification will then be developed allowing this additive to be used within the military's ground vehicle fleet. This process assures DOD monitoring and testing of potentially beneficial aftermarket and lubricant products."

The following claims were made by QMI regarding their additive products [2]:

> "Use of QMI will accomplish the following for DOD fleet maintenance:
>
> - Significantly reduce the cost and frequency of maintenance on most all equipment except turbine engines
> - Reduce the wear on all new equipment, therefore extending the useful life
> - Provide for a "field reset" on a good percentage of equipment in theatre
> - Easier starting in extreme conditions
> - Significantly reduced emissions"

QMI determined the appropriate additives and respective concentration levels for TFLRF to evaluate. Both analytical property tests and performance tests were conducted. A phased approach was followed. For the fuel additive, physical property tests, exhaust emissions tests, fuel economy tests, and a diesel engine deposition test were conducted. For the engine oil and gear oil additives, physical property tests were conducted first to determine if the additive was acceptable. The more expensive engine and gear tests would follow in a second phase if the property tests were acceptable. The analytical tests measured the properties of fuels, engine oils and gear lubricants both with and without the supplemental additive present. The performance testing compared results of a neat fuel to the fuel plus additive. The evaluations were conducted using JP-8 fuel because it is the recommended fuel for battlefield use.

NSWCCD provided the following additives as Government Furnished Material (GFM) for the work effort:

1. QMI Gear Treatment with PTFE
2. QMI Fuel Treatment
3. QMI Engine Treatment with PTFE

2.0 EVALUATION OF QMI FUEL ADDITIVE

2.1 Fuel Properties

JP-8 fuel (AL-26936[1]) was blended with QMI fuel additive (AL-27114) at the recommended rate of one ounce to five gallons of fuel (0.156% volume). The resultant blend (AL-27130) was submitted for analytical property tests. The results are presented in Tables 1 and 2. A column showing change in property, defined as Blend Property minus Base Fuel Property is also included in the tables. This will help illustrate the overall effect of the QMI fuel additive on a given JP-8 property. It should be noted that this batch of JP-8 had an unusually low conductivity value. This should not affect other property tests.

[1] AL- numbers designated specific sample identifications

Table 1. JP-8 Fuel Blend Property Results

Property	Units	ASTM Test Method	MIL-DTL-83133 (JP-8) Specification Requirements	JP-8 Base Fuel AL-26936	Blend[2] AL-27130	Change (Δ)[3]
Ball-On-Cylinder Lubricity Evaluator, avg. wear scar diameter	Mm	D 5001	NR (0.65, max per MIL-PRF-25017)	0.51	0.53	+0.02
Color, Saybolt		D 156	Report	+15	26	+11
Conductivity	pS/m	D 2624	[4]	10	1	-9
Copper Strip Corrosion, 2 hr @ 100°C	Visual rating	D 130	1, max	1A	1A	0
Density @ 15°C	kg/m^3	D 4052	775 - 840	793.0	793.0	0
Distillation	°C @ vol% evap.	D 86				
	IBP		Report	—	144	
	10		205, max	160	158	-2
	20		Report	166	165	-1
	30		—	—	171	
	40		—	—	180	
	50		Report	190	189	-1
	60		—	—	199	
	70		—	—	209	
	80		—	—	221	
	90		Report	235	235	0
	95		—	—	245	
	FBP		300, max	256	253	-3
• Residue	Vol %		1.5, max	1.2	1.0	-0.2
• Loss	Vol %		1.5, max	0.4	1.6	+1.2
Existent Gum	mg/100 ml	D 381	7.0, max	<0.1	<0.5	0
Flash Point	°C	D 3828	38, min	41	41	0
Freezing Point	°C	D 5972	-47, max	-48	-48	0
Cetane Index		D 976	Report	45	45	0
Hydrogen Content	mass %	D 5291	13.4, min	13.15	13.88	+0.73
Kinematic Viscosity @ -20°C	cm^2/s	D 445	8.0, max	3.48	3.51	+0.03

[2] Blend of AL-26936 (JP-8): AL-27116 (QMI Fuel Treatment) @ 1 oz. / 5 gal. of fuel.
[3] It should be noted that increases or decreases in a given property might be adverse or beneficial depending on the specific property and its specification requirement.
[4] The conductivity must be between 150 and 450 pS/m for F-34 (JP-8) at ambient temperature or 29.4°C (85°F), whichever is lower, unless otherwise directed by the procuring activity.

Table 1. JP-8 Fuel Blend Property Results (continued)

Property	Units	ASTM Test Method	MIL-DTL-83133 (JP-8) Specification Requirements	JP-8 Base Fuel AL-26936	Blend[5] AL-27130	Change (Δ)[6]
Microseparometer		D 3948	[7]	97	51	-46
Naphthalenes	vol%	D 1840	3.0, max	1.62	1.62	0
Net Heat of Combustion	MJ/kg	D 240	42.8, min	43.6	43.1	-0.5
Smoke Point	mm	D 1322	25, MIN	25	28	0
Sulfur, Mercaptan	mass %	D 3227	0.002, max	<0.0003	<0.0003	0
Sulfur, Total	ppm	D 5453	3000, max	87	94	+7
Thermal Oxidation Stability (JFTOT), 260°C	Change in pressure drop, mm Hg Heater tube deposit, visual rating	D 3241	25, max <3[8]	1 <2	0 1	-1
Total Acid Number	mg KOH/g	D 3242	0.015, max	0.011	0.007	-0.004

[5] Blend of AL-26936 (JP-8): AL-27116 (QMI Fuel Treatment) @ 1 oz. / 5 gal. of fuel.

[6] It should be noted that increases or decreases in a given property might be adverse or beneficial depending on the specific property and its specification requirement.

[7] The minimum Microseparometer rating using a Micro-Separometer (MSEP) shall be as follows:

JP-8 Additives	MSEP Rating, min.
Antioxidant (AO)*, Metal Deactivator (MDA)*	90
AO*, MDA*, and Fuel System Icing Inhibitor (FSII)	85
AO*, MDA*, and Corrosion Inhibitor/Lubricity Improver (CI/LI)	80
AO*, MDA*, FSII, and CI/LI)	70
**Even though the presence or absence does not change these limits, samples submitted for specification conformance testing shall contain the same additives present in the refinery batch. Regardless of which minimum the refiner elects to meet, the refiner shall report the MSEP rating on a laboratory hand blend of the fuel with all additives required by the specification.*	

[8] Peacock or abnormal color deposits result in a failure.

Table 2. Diesel Fuel Property Results of Base JP-8 Fuel and Blend

Property	Units	ASTM Test Method	JP-8 Base Fuel AL-26936	Blend* AL-27130	Blend-Base Δ
Carbon Residue on 10% bottom	wt. %	D 524	0.02	0.02	0
Cloud Point	Deg. C	D 2500	-56	-55	+1
Ash Content	mass %	D 482	<0.001	<0.001	0
Particulate Contamination	mg/l	D 5452	0.2	0.5	+0.3
Thermal Stability @ 150°C	% Reflectance	D 6468	99	99	0
Scuffing load BOCLE	grams	D 6079	2150	3300	+1150
HFRR	µm	D 6078	720	550	-170
Kinematic Viscosity @ 40°C	cSt	D 445	1.14	1.17	+0.03
Cetane Number		D 613	50	47	-3
Nitrogen	ppm	D 3228	2.7	2.8	+0.1
Filterability		IP 387	1.0	1.0	0
**Blend of AL-26936 (JP-8): AL-27116 (QMI Fuel Treatment) @ 1 oz. / 5 gal. of fuel.*					

The property changes caused by the QMI fuel additive are discussed below:

- Cetane number was reduced 3 numbers (test repeatability is 0.9 CN).
- Microseparometer rating was reduced to 51, which is below the minimum required by JP-8 specification. This test is used to "rate the ability of aviation turbine fuels to release entrained or emulsified water when passed through a fiberglass coalescing material [3]," and provides an indication of surfactant presence. The reduction of rating from 97 to 51 indicates that the QMI fuel additive imparted surfactant properties in the fuel.
- Conductivity was reduced by 9 pS/m.
- Distillation loss was out of specification for the blend.
- Wear scar diameter Ball on Cylinder Lubricity Evaluator (BOCLE) increased 0.02 mm.
- Cloud point was increased by 1°C.
- Particulate contamination was increased 0.3 mg/l.

The changes mentioned above could drive a given fuel sample outside JP-8 or diesel fuel specification limits, especially if the fuel had borderline properties.

The QMI fuel additive did improve the lubricity of the JP-8 fuel as determined by the High Frequency Reciprocating Rig (HFRR), American Society for Testing and Materials (ASTM) test method D 6078 and the Scuffing Load Ball on Cylinder Lubricity Evaluator (SLBOCLE), ASTM test method D 6079. These lubricity tests relate to fuel lubricity requirements for ground

vehicles and equipment, while the BOCLE test D 5001 is related to protection of aviation equipment.

2.1.1 Filterability by IP387

A filterability test method was used for both the JP-8 base fuel and the QMI blend in JP-8, as shown in Table 2. Filter blocking tendency results were 1.0 (dimensionless number) for both samples. There is no set limit in industry, but a maximum value of 1.41 is sometimes used. The QMI fuel additive had no effect on filter blocking tendency.

2.1.2 Water Separation ASTM D 1401

The impact of the QMI fuel additive on water separability was determined. A low sulfur diesel fuel meeting ASTM D 975 specification (AL-27169) and the same fuel treated with the recommended concentration of QMI fuel additive were tested according to ASTM D 1401 (Water Separability of Petroleum Oils and Synthetic Fluids) as per the requirements of MIL-PRF-16884K. The 25°C results were:

	Oil Layer	Water Layer	Emulsion Layer	Minutes
AL-27169 (Diesel Fuel)	40 ml	40 ml	0 ml	1.0
AL-27173 (Diesel Fuel) + QMI	40 ml	40 ml	0 ml	4.0
Δ	0	0	0	+3

The USN requirement for settling time is 10 minutes maximum. The fuel with QMI had an increased settling time of 3 minutes. The increase in settling time could cause some fuels blended with QMI fuel additive to fail the test. It should be noted that the QMI fuel additive was not evaluated in high Sulfur fuel, and the results of the low Sulfur fuel should not be extrapolated to high Sulfur fuel.

2.2 Diesel Engine Deposit Testing Using QMI Fuel Additive

The effect of the QMI fuel additive on diesel engine deposits was determined using the CAT 1K/1N test procedure, except for the use of JP-8 fuel which made these “nonstandard” tests, as stated in the test reports of Appendices 1 and 2. This procedure was conducted in a single-cylinder Caterpillar diesel engine with an aluminum piston that is operated at 2100 rpm and 70 bhp for 252 hours. Upon test completion, the engine was disassembled and the piston was rated for deposits using a standard Coordinating Research Council (CRC) demerit procedure. The piston ring wear and cylinder bore polish was also determined.

The baseline Caterpillar 1K/1N, 252-hour test, was completed using JP-8 fuel and Army MIL-PRF-2104G, SAE 15W40 reference oil. Following that, the engine was rebuilt and the test was completed using the same Army reference oil and JP-8 fuel treated with QMI fuel additive at the recommended rate of 1 oz. / 5 gal. of fuel. The CAT 1K/1N test results are presented in Table 3.

Table 3. Diesel Engine Deposit Results

Piston Deposit Rating, Demerits	JP-8	JP-8 + QMI	Δ
WDK/WDN	176.4	276.1	+99.7
Top Groove Fill, TGF%	14	44	+30
Top Land Hard Carbon, TLHC%	0	0	0
Oil Consumption			
BSOC, g/kw-h	0.21	0.21	0
EOTOC, g/kw-h	0.16	0.20	+0.04

The change in parameters (Δ) between the two tests is shown as JP-8 with QMI Results minus Baseline Results. This will assist in illustrating the effects of the QMI fuel additive. The results obtained for JP-8 and the reference oil would be considered a pass for API Service Classification CI-4. The results for JP-8 plus QMI fuel additive and the reference oil do not meet the requirements of API CI-4, because of increased piston top groove deposit. Overall, the QMI fuel additive appeared to cause an increase in piston deposits based on a single test run. The complete test reports are in Appendix 1 (JP-8 baseline) and Appendix 2 (JP-8 + QMI Fuel Additive).

2.3 Exhaust Emissions and Fuel Economy Using QMI Fuel Additive

Exhaust emissions and fuel economy effects of the QMI fuel additive were determined in a diesel engine pickup truck powered by a 6.6L Duramax engine. Figure 1 shows the test vehicle on a chassis dynamometer, while Figure 2 shows the tailpipe exhaust sampling system. The vehicle was operated over the FTP 75-test cycle and the Highway Fuel Economy Test Cycle (HwFET). The complete test results and details are shown in Appendix 3 (Final Letter Report, "Diesel Fuel Effects on Fuel Economy and Exhaust Emissions," SwRI Project 03.03227.36.202).

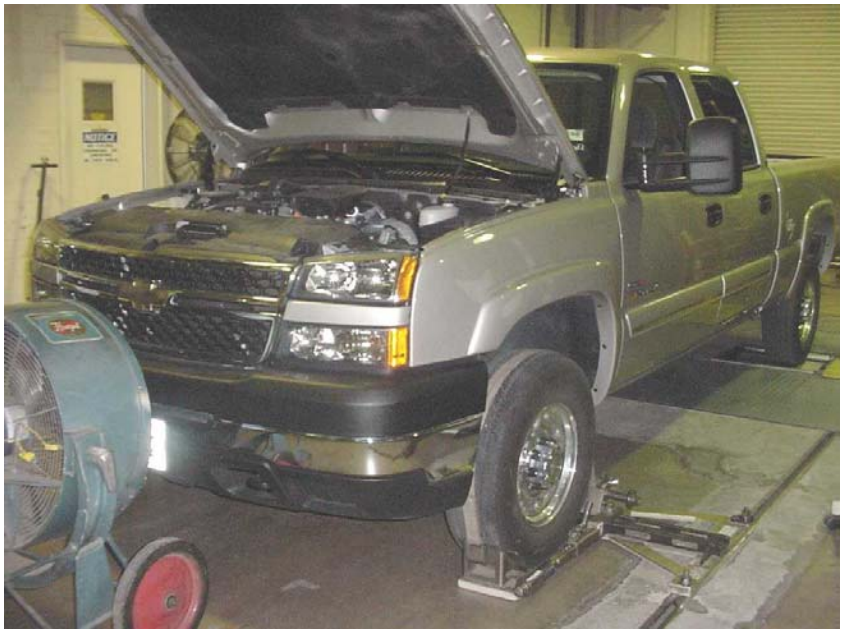


Figure 1. Test Vehicle on a Chassis Dynamometer

Figure 2. Tailpipe Exhaust Sampling System

The summarized results of the Fuel Economy testing are presented in Table 4.

Table 4. Fuel Economy Results

Fuel Type	FTP, mpg	HwFET, mpg	Composite, mpg
JP-8 Base Fuel, Avg. of 5 tests	13.10	19.45	15.36
STDV	0.077	0.156	0.068
COV, %	0.59	0.80	0.44
JP-8 + Additive, Avg. of 6 tests	13.33	19.74	15.61
STDV	0.135	0.225	0.146
COV, %	1.01	1.14	0.93
% Change with Additive	1.72	1.47	1.63
Statistically Significant Change			
at 95% C.L.	Yes	Yes	Yes
at 99% C.L.	Yes	No	Yes

Overall, the fuel containing the QMI additive produced a slight (<2%) but statistically significant (95% C.L.) improvement in vehicle fuel economy.

Results of the exhaust emissions are presented in Table 5. There were no statistically significant changes in NOx or PM produced by the JP-8 fuel with and without the QMI fuel additive over the weighted FTP and HwFET. There was a statistically significant increase in hydrocarbons (11%) and CO (5%) weighted FTP exhaust emissions with the JP-8 + QMI Fuel Additive.

Table 5. Exhaust Emissions Results

Test No.		Weighted FTP-75				Weighted HwFET			
		THC	CO	NO_X	PM	THC	CO	NO_X	PM
		g/mi	g/mi	g/mi	mg/mi	g/mi	g/mi	g/mi	mg/mi
Unadditized Fuel	Test 1	0.447	1.936	6.004	109.8	0.247	0.795	4.612	62.3
	Test 2	0.474	1.933	6.074	107.9	0.243	0.785	4.632	63.2
	Test 3	0.521	2.023	6.251	110.9	0.251	0.794	4.736	72.8
	Test 4	0.473	1.985	6.123	120.6	0.243	0.788	4.539	71.1
	Test 5	0.479	1.934	5.989	120.5	0.242	0.767	4.555	72.0
	Average	0.479	1.962	6.088	113.9	0.245	0.786	4.615	68.28
Additized Fuel	Test 1	0.537	2.146	6.191	108.2	0.265	0.801	4.530	49.6
	Test 2	Void							
	Test 3	Void							
	Test 4	0.520	2.030	5.978	107.6	0.248	0.782	4.574	68.9
	Test 5	0.536	2.100	6.275	99.2	0.272	0.805	4.665	68.6
	Test 6	0.524	2.017	6.136	108.2	0.264	0.800	4.612	69.8
	Test 7	0.539	2.111	5.713	138.6	0.266	0.806	4.619	68.8
	Test 8	0.543	2.061	6.008	133.1	0.257	0.825	4.495	66.7
	Average	0.533	2.078	6.050	115.8	0.262	0.803	4.583	65.40
Percent change from Unadditized to Additized Fuel		11.4%	5.9%	-0.6%	1.6%	6.9%	2.2%	-0.7%	-4.2%
Statistically significant at 95 percent CI*		YES	YES	NO	NO	YES	NO	NO	NO
Statistically significant at 99 percent CI†		YES	YES	NO	NO	YES	NO	NO	NO

**Based on student's t-test with 95 percent confidence interval*
†Based on student's t-test with 99 percent confidence interval

3.0 EVALUATION OF QMI ENGINE TREATMENT WITH PTFE

3.1 Engine Oil Properties

Blend (AL-27120) was made and submitted for property inspection tests. The blend contained Army MIL-PRF-2104G, SAE 15W40 reference engine oil (AL-26923) 80% vol., 20% vol. QMI engine oil additive (AL-27118) which is the recommended treatment rate. Results are presented in Table 6. A column showing change in property defined as blend property minus reference oil property is included in the table. This will help illustrate the magnitude and direction of the additive effects on properties.

Table 6. Engine Oil Inspections

Property	Units	ASTM Test Method	MIL-PRF-2104G Specification Limits	Test Results		
				Army MIL-PRF-2104G Ref Eng. Oil AL-26923	Blend: Army Ref. Oil w/QMI Add. @ 20% vol. AL-27120	Blend-Base* Δ
Kinematic Viscosity @ 100°C	cSt	D 445	12.5 min. <16.3 max.	14.4	13.3	-1.1
Kinematic Viscosity @ 40°C	cSt	D 445	Report	113.32	102.19	-11.13
Viscosity Index	—	D 2270	Report	129	128	-1
Foaming Characteristics		D 892				
Seq. I (5 minutes blow/10 minutes settle)	ml/ml	D 892	10/0 max.	0/0	0/0	0
Seq. II (5 minutes blow/10 minutes settle)	ml/ml	D 892	20/0 max.	60/0	30/0	-30/0
Seq. III (5 minutes blow/10 minutes settle)	ml/ml	D 892	10/0 max.	0/0	0/0	0
Flash Point	°C	D 92	215 min.	228	220	-8
Pour Point	°C	D 97	-23 max.	-36	-36	0
API Gravity	degrees	D 287	Report	28.1	28.7	+0.6
Sulfur	mass %	D 2622	Report	0.71	0.59	-0.12
Sulfated Ash	mass %	D 874	Report	0.93	0.93	0
Barium	mass %	D 5185	Report	<0.0001	<0.0001	0
Boron	mass %	D 5185	Report	0.0006	0.0011	+0.0005
Phosphorous	mass %	D 5185	Report	0.1048	0.1211	+0.0163
Potassium	mass %	D 5185	Report	<0.0005	<0.0005	0
Silicon	mass %	D 5185	Report	0.0002	0.0002	0
Zinc	mass %	D 5185	Report	0.1172	0.1084	-0.0088
Carbon Residue	mass %	D 524	Report	1.01	1.04	+0.03
Borderline Pumping Temp. Test Apparent Viscosity @ -25°C	cP	D 4684	60,000 max.	49,200	22,600	-26,600
Yield Stress	Pa		None	NYS	NYS	0
Apparent Viscosity @ -20°C	cP	D 5293	3,500 min.	8,300	6,310	-1990
Evaporation Loss @ 245.2°C	mass %	D 5800B	15 max.	11.1	11.2	+0.1
Stable Pour Point	°C	FTM 203	-23 max.	-38	-38	0
Eng. Oil Homo. & Miscibility	None	D 6922	Pass	Pass	Pass	0

**It should be noted that increases or decreases in a given property might be adverse or beneficial depending on the specific property and its specification requirement.*

The blend with QMI engine oil additive had the following property changes:

- Viscosity at 100°C decreased by 1.1 cSt to 13.3 cSt. For some oil formulations, a decrease of 1.1 cSt at 100°C could force the oil to a lower SAE viscosity grade.
- Viscosity at 40°C decreased by 11.13 cSt. Specification requirement is report only.

- Flash point was reduced 8°C. This change in flash point could force some oils below the minimum specification requirement.

- Better low-temperature pumpability because of decrease in apparent viscosity.

- The Army reference oil failed the Sequence II Foam Content. The blend with QMI additive improved the Sequence II Foam Content, but the blend still failed.

The following properties have report only specification:

- Sulfur content reduced by 0.12% mass.

- Increase in Boron and Phosphorus of 5 ppm.

- Increase in Phosphorus of 163 ppm.

- Decrease in Zinc content of 88 ppm.

4.0 EVALUATION OF QMI GEAR OIL TREATMENT WITH PTFE

4.1 Gear Oil Properties

Phillips 66 SMP 80W90 gear oil (GLO142) AL-27121, 80% vol., was blended with 20% QMI gear oil additive (AL-27117). This is the recommended treatment rate for the QMI gear oil additive. The blend (AL-27123) was submitted for property inspection tests. Results are presented in Table 7. The blend with QMI gear oil additive had the following property changes:

- Viscosity at 100°C increased by 0.32 cSt. This change could force a given oil above the viscosity maximum in the specification.

- Low temperature Brookfield Viscosity @ -26°C increased by 4000 cp. This change could force a given oil above the specification maximum.

- Flash point was reduced 10°C. This change could force a given oil below the specification minimum.

- Additive caused the base gear to fail the Sequence II Foam Settling. This additive has the potential to cause all gear oils to fail the Sequence II Settling requirement of 0 ml maximum.

The following properties have report only specification:

- Pentane insolubles increased by 0.06 wt. %.
- Boron increased slightly (24 ppm).
- Phosphorus increased (0.01%).
- Increase in Zinc of 4 ppm.

Table 7. Gear Oil Inspections

Property	Units	Test Method	MIL-PRF-2105E Specification Limits, SAE J 306 80W90 Grade	Test Results		
				SMP Gear Lubricant AL-27121	SMP Gear Lubricant/Add QMI @ 20% vol. AL-27123	Blend-Base* Δ
Kinematic Viscosity @ 100°C	cSt	D 445	13.5 min. <24.0 max.	14.9	15.2	+0.3
Kinematic Viscosity @ 40°C	cSt	D 445	Report	149.5	153.2	+3.7
Viscosity Index	—	D 2270	Report	99	100	+1
Brookfield Viscosity @ -26°C	cP	D 2983	150,000 max.	133,000	137,000	+4000
Channeling Point @ -35°C	None	FTM 3456.2	Non-Channeling	Non-Channeling	Non-Channeling	0
Copper Corrosion (121°C, 3hrs)	—	D 130	ASTM No. 3 max	1b	1b	0
Foaming Characteristics		D 892				
Seq. I (5 minutes blow/10 minutes settle)	ml/ml	D 892	20/0 max.	0/0	0/0	0
Seq. II (5 minutes blow/10 minutes settle)	ml/ml	D 892	50/0 max.	0/0	20/18	+20/18
Seq. III (5 minutes blow/10 minutes settle)	ml/ml	D 892	20/0 max.	0/0	0/0	0
Flash Point	°C	D 92	165 min.	224	214	-10
Pour Point	°C	D 97	Report	-30	-30	0
API Gravity	—	D 287	Report	27.7	27.4	-0.3
Pentane Insolubles	mass %	D 893	Report	0.01	0.07	+0.06
Sulfur	mass %	D 2622	Report	1.7695	1.8331	+0.0636
Nitrogen	mass %	D 3228	Report	0.08	0.09	+0.01
Chlorine	mass %	D 808	Report	<0.05	0.07	+0.02
Sulfated Ash	mass %	D 874	—	0.02	0.05	+0.03
Barium	mass %	D 5185	Report	<0.0001	<0.0001	0
Boron	mass %	D 5185	Report	0.0001	0.0025	+0.0024
Phosphorous	mass %	D 5185	Report	0.0631	0.0745	+0.0114
Potassium	mass %	D 5185	Report	<0.0005	<0.0005	0
Silicon	mass %	D 5185	—	0.0003	0.0002	-0.0001
Zinc	mass %	D 5185	Report	0.0001	0.0005	+0.0004
Storage Stability & Compatabiliy	—	FTM 3430/3440	—	Acceptable	Acceptable	0

**It should be noted that increases or decreases in a given property might be adverse or beneficial depending on the specific property and its specification requirement.*

5.0 CONCLUSIONS

With respect to physical and chemical properties, the magnitude of change caused by the additive is one of the key aspects. If the military products being used are at the edge of their respective specification limits, the change, even if minor, caused by an additive can drive the product properties outside of specification limits.

5.1 Fuel Additive Effects

For the QMI fuel additive, the following property results showed an adverse change:

- Cetane number reduced by 3 numbers.
- The additive appeared to impart surfactant properties as evidenced by a substantially reduced Microseparometer rating, and extended time to separate in the D 1401 Water Separation test.
- Increases in Cloud Point, particulate contamination and BOCLE wear scar.

The QMI fuel additive produced the following positive effects:

- Fuel lubricity for ground vehicle applications was improved as measured in the SLBOCLE and HFRR bench tests.
- A slight (<2%) statistically significant (95% CL) improvement in fuel economy was measured in a vehicle.

In addition, the following impacts were measured: The QMI fuel additive had no significant effect on PM or NOx exhaust emissions. There was a statistically significant increase in total hydrocarbon exhaust emissions, with the values remaining very low. There was a statistically significant (95% CL) increase in CO observed in the weighted FTP.

Based on Cat 1K/1N engine tests, increased piston deposits were observed with the QMI fuel additive in the JP-8 fuel. The increase in piston top groove deposits was sufficient to fail the requirements of API specification limits for CI-4.

5.2 Engine Oil Properties and Additive Effects

The following adverse property effects were observed for the QMI engine oil additive:

- Decreased Kinematic Viscosity at 100°C by 1.1 cSt.
- Reduced Flash Point by 8°C.

The potential positive effects of the additive were:

- Improved low temperature engine oil properties.

- Improvement in engine oil anti-foam properties.

5.3 Gear Oil Properties and Additive Effects

The adverse property effects of QMI gear oil additive were:

- An increase in low temperature viscosity.
- A decrease in Flash Point of 10°C.
- Increase oil foaming characteristics.

An increase in Kinematic Viscosity at 100°C of +0.3 cSt was noted.

All three QMI additives failed to meet the "no adverse side effects" criterion of the DOD after-market additive policy guidelines.

6.0 REFERENCES

1. U.S. Department of Defense, "Department of Defense Policy Guidelines for Use of After-Market Fuel and Lubricant Additives," July 1996.

2. Mangham, John (of QMI), Letter to Michael Thomas, Chenowth, 27 January 2005.

3. American Society for Testing and Materials, "Annual Book of A.S.T.M. Standards," ASTM International, West Conshohocken, PA.

APPENDIX 1

Cat 1K/1N Test Using JP-8 Fuel and Army Reference Oil

1K/1N

Version 20040527

Title / Validity Declaration Page

Method 1K

Conducted for

SOUTHWEST RESEARCH INSTITUTE
ARMY LAB

N	V = Valid
	I = Invalid
	N = Results cannot be Interpreted as Respresentative of Oil Performance (Non-Reference Oil) and shall not be used for Multiple Test Acceptance Criteria

Test Number	
Test Stand: 62	**Engine Run No.:** 192
EOT Time: 19:45	**EOT Date:** 20051203
Oil Code / CMIR: * AL-26951-L	
Formulation / Stand Code: A	
Alternate Codes: B FUEL = JP-8 AL-~~27~~25T AL-27125	

In my opinion this test has not been conducted in accordance with the 1K/1N Test Procedure (Research Report RR:D02-1273/RR:D02-1321) and the appropriate amendments through the information letter system. The remarks included in the report describe the anomalies associated with this test.

The results of this report relate only to the items tested.

** CMIR or Non-Reference Oil Code*

A ACC -Registered Tests Only

B When Provided or Required by Client

Submitted by:

Southwest Research Institute (R)
Testing Laboratory

James F. McCord
Signature

James F. McCord
Typed Name

Research Engineer
Title

1K/1N
Test Report Summary
Form 1

Lab: SR	EOT Date: 20051203	END Time: 19:45	Method: 1K
Stand: 62	Run Number: 192		
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Start Date: 20051122	Total Test Length: 252	TMC Oil Type:
Laboratory Internal Oil Code: LO-206830		

	Correction Effective Date	WDK / WDN	TGF %	TLHC %	Transformed TLHC %	BSOC g/k W-h	EOTOC g/kW-h
Unadjusting Lab Rating		176.4	14	0	0.000	0.21	0.16
Industry Correction (if any)							
Subtotal		176.4	14		0.000	0.21	0.16
Lab Severity Adjustment (if any)[A]	20050616	0.0	0		0.000	0.00	0.00
Total		176.4	14	0	0.000	0.21	0.16

	Effective Date	WDK / WDN	TGF %	TLHC %	Transformed TLHC %	BSOC g/k W-h	EOTOC g/kW-h
Test Target Mean[B]							
Test Target STD[B]							
CI-4 Pass Limits (First-Test)[A,C]		332.0	24.0	4.0		0.50	0.50

	Referee Lab	WDK / WDN	TGF %
Referee Ratings			

	Top	Int. 1	Oil	Piston	Liner
Ring Loss of Side Clearance (mm)	0.286	0.095	0.095		
Ring End Gap Increase (mm)	0.051	0.026	0.026		
Is the Ring Stuck?	NO	NO	NO		
Scuffed Area %	0	0	0	0	0
Average Wear Step (mm)					0.019
% Bore Polish					7.0

Notes:
[A] *Non-reference tests only*
[B] *Reference tests only*
[C] *See Appendix X4*

1K/1N
Operational Summary
Form 2

Lab: SR	**EOT Date:** 20051203	**END Time:** 19:45	**Method:** 1K
Stand: 62	**Run Number:** 192	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Operating Condition		Minimum	Maximum	Average	Specification
Engine Speed	r/min	2089.0	2122.0	2100.0	2100 ± 10
Engine Power	kW	43.7	50.3	49.0	Report
Fuel Flow	g/min	173.0	187.5	184.9	185 ±1
Humidity	g/kg	14.9	19.5	17.6	17.8 ± 1.7
Temperature °C					
Coolant Out	°C	92.8	95.1	93.0	93 ± 2.5
Coolant In	°C	84.4	169.3	87.7	Report
Coolant delta T	°C	4.7	7.6	5.4	5 ±1.0
Oil To BRG	°C	106.1	108.6	107.0	107 ± 2.5
Oil Cooler In	°C	107.3	111.4	110.7	Report
Inlet Air	°C	126.5	127.6	127.0	127 ± 2.5
Exhaust	°C	515.6	571.7	564.6	550 ± 30
Fuel @ Injector Housing	°C	53.5	61.4	57.3	57 ± 3
Pressures					
Oil to Bearing	kPa	399.9	417.1	407.9	482 Max
Oil to Jet	kPa	353.0	364.7	358.1	360 ± 13
Inlet Air	kPa	239.1	241.1	240.1	240 ± 1
Exhaust (ABS)	kPa	215.0	217.1	216.1	216 ±1
Fuel @ Filter HSG	kPa	202.0	221.3	210.3	210 ± 20
Crankcase Vacuum	kPa	0.61	0.97	0.70	0.7 ± 0.1
Coolant Jug Pressure	kPa	22.1	92.4	41.7	Report
Flows					
Blowby	L/min	8.2	13.0	10.6	Report
Coolant Flow	L/min	59.0	71.2	64.8	65 ± 2

Air/Fuel Ratio 24 Hr:	28.9	Air/Fuel Ratio 252 Hr:	29.0

Assembly Measurement and Parts Record

Piston / Head Clearance mm:	3.632	Intake Valve Open °ATC:	3.0
		Fuel Flow Timing °BTC:	31.5

	Part No. (1)	Serial No. (2)	Date Code	Inspection Code
Liner	1Y3998	D02M11Y04P47	N/A [F]	BB71 [G]
Ring Set (1)	1Y0728		1201 [I]	4317 [H]
Piston	1Y0727	21001D1468D0	1171 (E) [D]	1001 [E]

(1) and (2) Number on Parts Box Yellow Label

[D] Number below "E" located on top of piston
[E] Number on top of "E" located on top of piston
[F] Four alphanumeric characters (NNAN) on liner O.D.
[G] Four digit number on liner O.D.
[H] Three or four digit number on white label on ring set box
[I] NN-NN from part number label on ring set box

1K/1N
Operational Summary - Offset and Deviation
Form 3

Lab: SR	**EOT Date:** 20051203	**END Time:** 19:45	**Method:** 1K
Stand: 62	**Run Number:** 192	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Controlled Parameter	Allowable % Out	This Test % Out	Allowable % Off	This Test % Off
Speed	5	0.1	20	0.0
Fuel Flow	10	5.1	25	4.5
Humidity	10	0.3	25	7.1
Coolant Flow	5	0.0	25	0.0
Temperature				
Coolant Out	5	0.0	20	6.4
Oil to Bearing	5	0.0	20	3.6
Intake Air	5	0.0	20	6.4
Fuel at Injector Housing	5	0.1	20	5.0
Pressures				
Oil Jet	5	0.0	25	1.4
Intake Air	10	0.0	25	0.0
Exhaust	10	0.0	25	2.4
Fuel at Filter Housing	5	0.0	20	0.0
Crankcase Vacuum	10	0.1	20	0.0

1N
Piston Rating Summary
Form 4

Test Identification	Lab: SR	EOT Date: 20051203	End Time: 19:45	Stand: 62	Run Number: 192	Method: 1K	Test Length: 252
Formulation / Stand Code:				Oil Code / CMIR: AL-26951-L			
Test Fuel: JP-8	Fuel Batch:	Date Rated: 20051207	Rating Number:		Rater: RBV		

Last Stand Reference Information	Date Completed:	Stand Number: 62	Run Number:	TMC Oil Code:

	WDK / WDN	TGF	TLHC	Transformed TLHC	BSOC	EOTOC
Last Reference This Stand						
Industry Average						
Industry Std						

Total Piston Ratings Summary

		Grooves						Lands						Upper Skirt		Under Crown		Pin Bores			
	Dep. Factor	No. 1		No. 2		No. 3		No. 1		No. 2		No. 3						Front		Rear	
		A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.
Carbon	HC-1.0			11	11.00					8	8.00										
	MC-0.5	14	7.00																		
	LC-.25	86	21.50	85	21.25			19	4.75	89	22.25										
	Total	100	28.50	96	32.25	0	0.00	19	4.75	97	30.25	0	0.00	0	0.00	0	0.00				
Lacquer	8 - 9							7	0.63												
	7 - 7.9																				
	6 - 6.9																				
	5 - 5.9																				
	4 - 4.9											2	0.10								
	3 - 3.9									3	0.09										
	2 - 2.9			4	0.11			17	0.48			15	0.36			5	0.12				
	1 - 1.9					10	0.17	17	0.23			20	0.24								
	>0 - 0.9					82	0.26	40	0.21			63	0.36	100	0.10	95	0.19				
	Clean		0		0	8	0		0		0		0		0		0		0		0
	Total	0	0.00	4	0.11	100	0.43	81	1.55	3	0.09	100	1.06	100	0.10	100	0.31				
Rating		28.50		32.36		0.43		6.30		30.34		1.06		0.10		0.31					
WDK LOC FCT		1.5		1.5		25		1		1		25		50		20		0		0	
Ind Rating		42.75		48.54		10.75		6.30		30.34		26.50		5.00		6.20					

TGF %	Int. GR. Fill %	WDK / WDN	Unweighted Dep.	T.L. Heavy Carbon %	T.L. Flaked Carbon %	ACC GR Fill %
14	19	176.4	99.4	0	0	26

1K/1N
Rating Worksheet

Method: 1K　Total Test Length: 252

Test No.: 62-192　Oil Code: AL-26951-L　Rater: RBV　EOT Date: 20051203

	Grooves														
	No. 1			No. 2			No. 3			Undercrown			Upperskirt		
	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem
Carbon		1.0		11	1.0	11.00		1.0			1.0			1.0	
Carbon	14	.50	7.00					.50							
Carbon	86	.25	21.50	85	.25	21.25		.25			.25			.25	
Carbon	100	Sub T	28.50	96	Sub T	32.25	0	Sub T	0.00	0	Sub T	0.00	0	Sub T	0.00
Varnish		10-10.0		4	10-7.2	0.11	10	10-8.3	0.17	5	10-7.5	0.12	100	10-9.9	0.10
Varnish		10-10.0			10-10.0		20	10-9.5	0.10	95	10-9.8	0.19		10-10.0	
Varnish		10-10.0			10-10.0		34	10-9.7	0.10		10-10.0			10-10.0	
Varnish		10-10.0			10-10.0		28	10-9.8	0.06		10-10.0			10-10.0	
Varnish		10-10.0			10-10.0		8	10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish	0	Sub T	0.00	4	Sub T	0.11	100	Sub T	0.43	100	Sub T	0.31	100	Sub T	0.10
Varnish		Total	28.50		Total	32.36		Total	0.43		Total	0.31		Total	0.10

	Lands									Pin Bores					
	No. 1			No. 2			No. 3			Front			Rear		
	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem
Carbon		1.0		8	1.0	8.00		1.0			1.0			1.0	
Carbon	19	.25	4.75	89	.25	22.25		.25			.25			.25	
Carbon	19	Sub T	4.75	97	Sub T	30.25	0	Sub T	0.00		Sub T			Sub	
Varnish	7	10-1.0	0.63	3	10-7.0	0.09	2	10-5.2	0.10		10-10.0			10-10.0	
Varnish	17	10-7.2	0.48		10-10.0		3	10-7.3	0.08		10-10.0			10-10.0	
Varnish	7	10-8.2	0.13		10-10.0		12	10-7.7	0.28		10-10.0			10-10.0	
Varnish	10	10-9.0	0.10		10-10.0		20	10-8.8	0.24		10-10.0			10-10.0	
Varnish	26	10-9.3	0.18		10-10.0		24	10-9.2	0.19		10-10.0			10-10.0	
Varnish	14	10-9.8	0.03		10-10.0		18	10-9.4	0.11		10-10.0			10-10.0	
Varnish		10-10.0			10-10.0		21	10-9.7	0.06		10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
Varnish	81	Sub T	1.55	3	Sub T	0.09	100	Sub T	1.06		Sub T			Sub T	
Varnish		Total	6.30		Total	30.34		Total	1.06		Total			Total	

	Grooves			Lands			Upper Skirt	Under Crown	Pin Bores	
	1	2	3	1	2	3			Front	Rear
Rating	28.50	32.36	0.43	6.30	30.34	1.06	0.10	0.31		
WDK LOC FCT	1.5	1.5	25	1	1	25	50	20	0	0
WT Rating	42.75	48.54	10.75	6.30	30.34	26.50	5.00	6.20		
TGF: 14	Intermidate Groove Fill: 19			WDK / WDN: 176.4			Top Land Heavy Carbon: 0			

1K/1N

Supplemental Piston Deposits (Groove Sides and Rings)

Form 5

Lab: SR	**EOT Date:** 20051203	**END Time:** 19:45	**Method:** 1K
Stand: 62	**Run Number:** 192	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Deposit Type			Carbon			Varnish									
			HC	MC	LC	8 - 9	7 - 7.9	6 - 6.9	5 - 5.9	4 - 4.9	3 - 3.9	2 - 2.9	1 - 1.9	>0 - 0.9	Clean
Groove Top and Bottom	1	T			35	45		20							
		B									30	50	20		
	2	T			15	70						15			
		B							10	20	10	60			
	3	T								10	20	55	15		
		B								15	15	70			
Top Bottom and Back of Rings	1	T			5	20	20	10			15	20	10		
		B										10		90	
		BK			100										
	2	T			5							85	10		
		B									70	10	5	15	
		BK			70							30			
	3	T										70	20	10	
		B										20	50	30	
		BK										75	25		

Additional Deposit & Condition Ratings

Piston Crown	Normal.
Liner	Normal.
Rings	Normal.

1K/1N
Oil Analysis and Results Summary
Form 6

Lab: SR	**EOT Date:** 20051203	**END Time:** 19:45	**Method:** 1K
Stand: 62	**Run Number:** 192	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			
Test Method: 1K	**Test Fuel:** JP-8	**Fuel Batch:**	

Oil Analysis / Engine Hours		NEW / 0		24		204		252	
Viscosity @ 100°C		15.07		13.65		14.00		14.36	
TBN D4739		6.81		5.14		3.55		3.11	
Wear Metals:	Fe / Al	4	<1	9	<1	29	1	33	1
	Si / Cu	5	<1	2	<1	5	2	5	2
	Cr / Pb	<1	<1	<1	<1	1	1	2	2
Fuel Dilution %				0.3		0.3		0.3	
Blowby (L/min)				9.4		11.2		11.2	

24 Hour Average BSOC (g/w-W-h) for Hours End				0-252 Hr. Avg. BSOC (g/k-W-h):		0.21	EOT Oil Consumption(g/kW-h):		0.16
24	48	72	108	132	156	180	204	228	252
0.30	0.23	0.24	0.25	0.22	0.25	0.15	0.17	0.16	0.13

Inspection and Measurement Summary	**Ring Gap Increase (mm)**	**Side Clearance Loss (mm)**	**Ring Stuck (1)**	**Scuffed Area % (2)**	**% Bore Polish (With Grid)**	**Average Wear Step (mm)**
Top Ring	0.051	0.286	NO	0		
Intermediate Ring	0.026	0.095	NO	0		
Oil Ring	0.026	0.095	NO	0		
Piston				0		
Cylinder Liner				0	7.0	0.019

Piston Deposit Summary	TGF %	Int. Gr. F.%	WDK	Un Wt Dep	T.L. Heavy Carbon	T.L. Flaked Carbon %
	14	19	176.4	99.4	0	0

Unweighted Piston Deposits

Grooves			**Lands**			**Upper Skirt**	**Under Crown**	**Pin Bores**	
1	2	3	1	2	3			Front	Rear
28.50	32.36	0.43	6.30	30.34	1.06	0.10	0.31		

1K/1N
Unscheduled Downtime & Maintenance Summary
Form 7

Lab: SR	**EOT Date:** 20051203	**END Time:** 19:45	**Method:** 1K
Stand: 62	**Run Number:** 192	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Number of Downtime Occurrences: 5

Test	Date	Downtime	Reasons
152:59	20051128	4:25	Drained coolant and replaced with new.
158:07	20051129	6:24	Replaced fuel heater tubing.
217:21	20051202	1:04	Replaced coolant out temp thermocouple.
232:03	20051202	1:34	Replaced coolant in temp thermocouple.
236:35	20051203	4:09	Cooling tower repairs.
Total Downtime		017:36	

Other Comments

Number of Comment Lines: 1

CAT 1K test run with JP-8 fuel.

1K/1N
Ring Measurements
Form 8

Lab: SR	**EOT Date:** 20051203	**END Time:** 19:45	**Method:** 1K
Stand: 62	**Run Number:** 192	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Ring Gaps (mm)	Top	Intermediate	OIL
Specifications	0.724 ± 0.076 mm	0.673 ± 0.076 mm	0.572 ± 0.190 mm
Pre-Test	0.711	0.660	0.584
Post-Test	0.762	0.686	0.610
Increase	0.051	0.026	0.026

Ring Side Clearance *		A	B	C	D	Average	Minimum	Specification
Top	Pre-Test	1.651	1.651	1.651	1.651	1.651	1.651	0.193±0.032 mm
	Post-Test	1.397	1.270	1.270	1.524	1.365	1.270	
	LSC	0.254	0.381	0.381	0.127	0.286	0.127	
Intermediate	Pre-Test	0.762	0.762	0.762	0.762	0.762	0.762	0.090±0.020 mm
	Post-Test	0.762	0.635	0.635	0.635	0.667	0.635	
	LSC	0.000	0.127	0.127	0.127	0.095	0.000	
Oil	Pre-Test	0.635	0.635	0.635	0.635	0.635	0.635	0.073 ±0.016 mm
	Post-Test	0.635	0.508	0.508	0.508	0.540	0.508	
	LSC	0.000	0.127	0.127	0.127	0.095	0.000	

* Notes:

1. Write "Stuck" In Place of Dimension When Applicable.

2. Write "<0.038 mm" For Clearance When Applicable.

3. Write ">" Before Calculated Decrease or Average Decrease Values That Incorporate a "<0.038 mm" in Calculation.

4 LSC: Loss of Clearance.

5. Minimum: Intermediate and Oil Ring Minimum Side Clearance is Measured 360° Around Piston.

1K/1N
Liner Measurements
Form 9

Lab: SR	**EOT Date:** 20051203	**END Time:** 19:45	**Method:** 1K
Stand: 62	**Run Number:** 192	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Liner Surface Finish (micrometer)			
Distance From Top	**Transverse**	**Longitudinal**	**Average**
130 mm	0.40	0.39	0.40
50 mm	0.36	0.46	0.41
25 mm	0.31	0.38	0.34
		Total Average:	0.38

% Liner Bore Polish - Grid (Add T/AT Values From Grid)	
Thrust	3.0
Anti-Thrust	4.0
Total	7.0

Liner Bore Measurement (mm)		
Before Test - Diameter (Dial Bore Gage)		
Bore Height	**Longitudinal**	**Transverse**
230 mm	137.168	137.173
130 mm	137.170	137.180
50 mm	137.168	137.183
25 mm	137.173	137.203
15 mm	137.173	137.203

After Test - (Surface Profile)				
	Longitudinal		**Transverse**	
	Front	Rear	T	AT
Wear Step @ 15mm	0.018	0.020	0.020	0.018

1K/1N

Characteristics of the Data Acquisition System

Form 10

Lab: SR	EOT Date: 20051203	END Time: 19:45	Method: 1K
Stand: 62	Run Number: 192	Total Test Length: 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Parameter (1)	Sensing Device (2)	Calibration Frequency (3)	Record Device (4)	Observation Frequency (5)	Record Frequency (6)	Log Frequency (7)	System Response (8)
Operation Conditions							
Engine Speed (r/min)	Magnetic Pickup	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.1
Engine Power (kW)	Load Cell	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	1.9
Fuel Flow (kJ/min)	Micro-Motion	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	70.3
Humidity (g/kg)	Dew Cell	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	6.0 min
Temperatures (°C)							
Coolant Out	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.8
Coolant In	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.7
Oil to Bearing	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.9
Oil Cooler In	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	3.0
Inlet Air	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.8
Exhaust	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.9
Pressure (kPa)							
Oil to Bearing	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.9
Oil to Jet	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.0
Inlet Air	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	1.0
Exhaust	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	3.0
Fuel @ Filter HSG	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.8
Crankcase Vacuum	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	3.0
Flows (L/min)							
Blowby	Gas Meter	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	10.0
Coolant Flow	Barco Venturi	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	3.0

Legend:

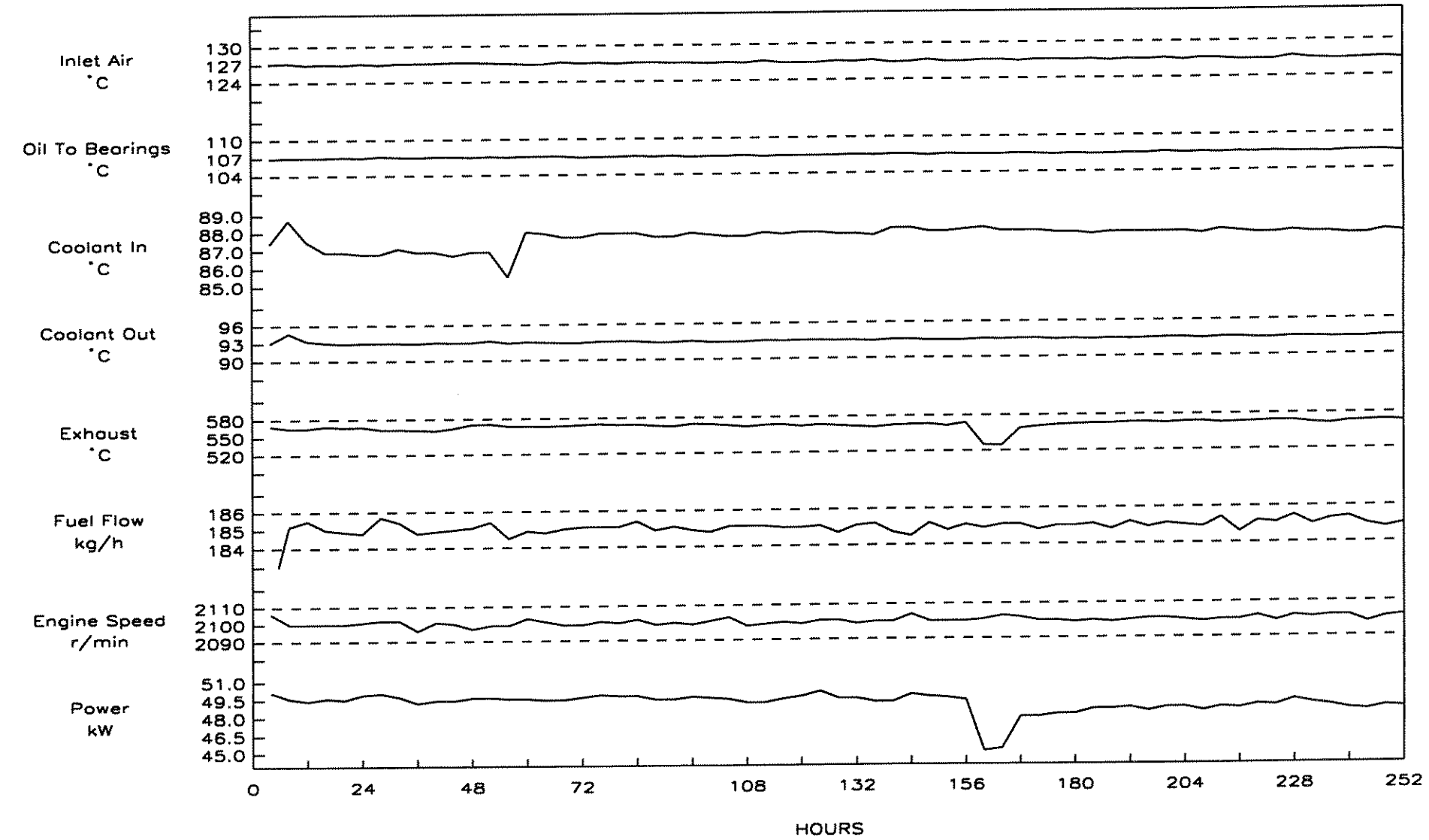
(1) Operating Parameter
(2) The Type of Device Used to Measure Temperature, Pressure, or Flow
(3) Frequency at Which the Measurement System is Calibrated
(4) The Type of Device Where Data is Recorded
- LG - Hanglog Sheet
- DL - Automatic Data Logger
- SC - Strip Chart Recorder
- C/M - Computer, Using Manual Data Entry
- C/D - Computer, Using Direct I/O Entry

(5) Data Area Observed but Only Recorded if off Spec.
(6) Data are Recorded but are not Retained at EOT
(7) Data are Logged as Permanent Record, Note Specify if:
- SS - Snapshot Taken at Specified Frequency
- AG/X - Average of X Data Points at Specified Frequency

(8) Time for the Output to Reach 63.2% of Final Value for Step Change at Input

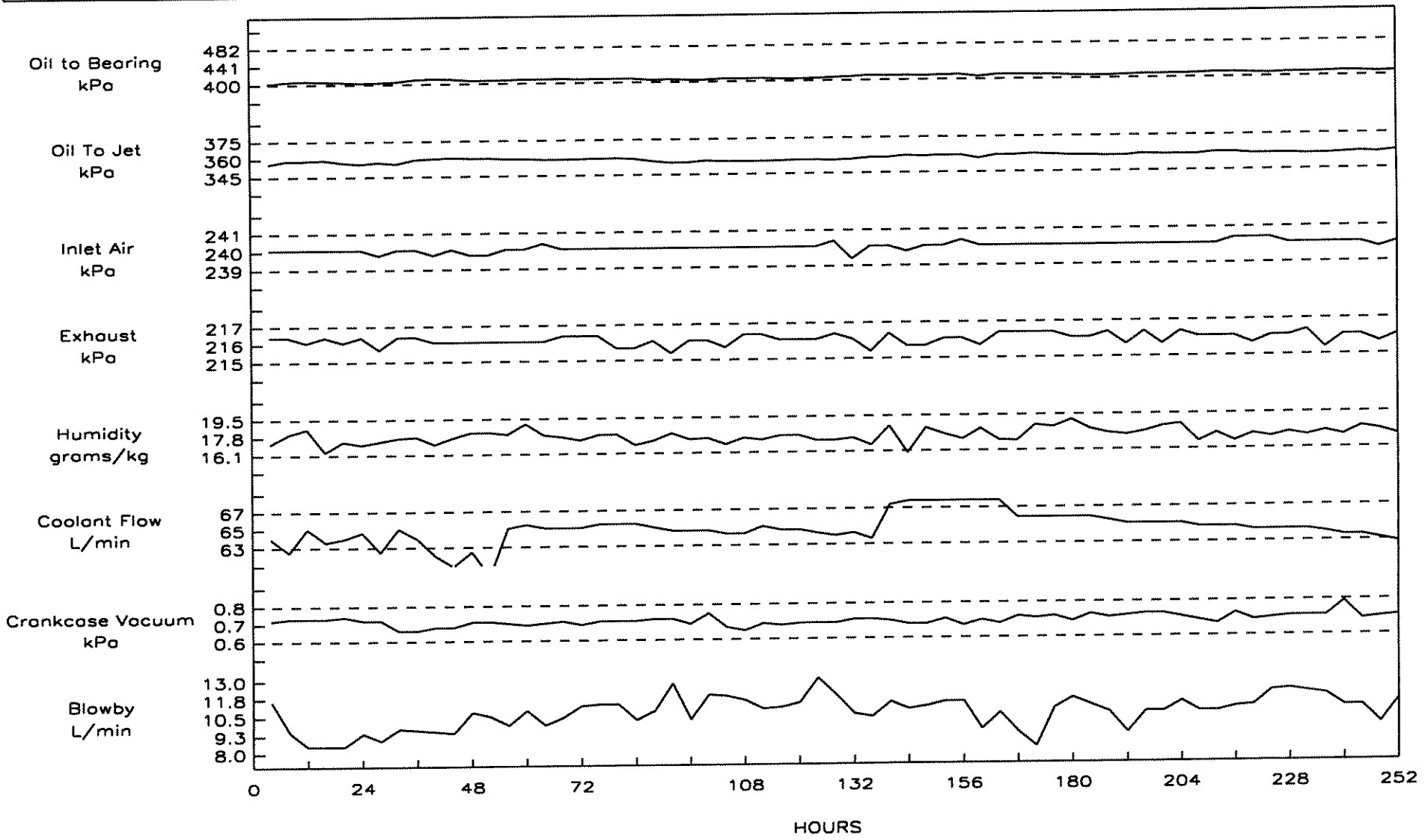
1K/1N
FORM 11

LAB: SR	EOT DATE: 20051203	END TIME: 19:45	METHOD: 1K
STAND: 62	RUN NUMBER: 192		
FORMULATION/STAND CODE:			
OIL CODE/CMIR: AL-26951-L			



1K/1N
FORM 12

LAB: SR	EOT DATE: 20051203	END TIME: 19:45	METHOD: 1K
STAND: 62	RUN NUMBER: 192		
FORMULATION/STAND CODE:			
OIL CODE/CMIR: AL-26951-L			



1K/1N
FORM 13
OIL CONSUMPTION PLOT

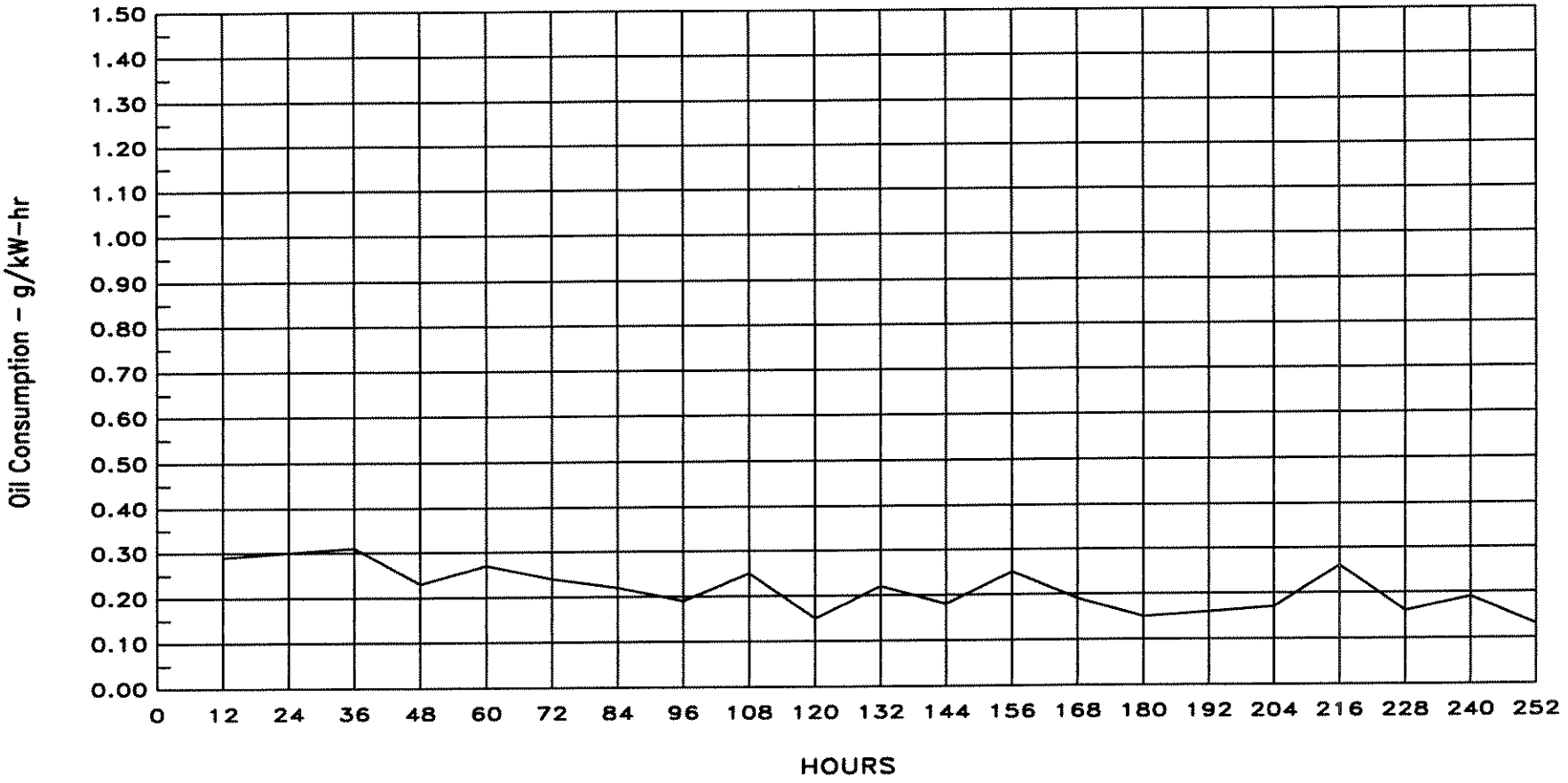
LAB: SR	EOT DATE: 20051203	END TIME: 19:45	METHOD: 1K
STAND: 62	RUN NUMBER: 192		
FORMULATION/STAND CODE:			
OIL CODE/CMIR: AL-26951-L			

0 – 24 Hour 0.30

228 – 252 Hour 0.16

Avg 0 – 252 Hour 0.21

Increase 0 – 24 to 228 – 252 Hour −0.17 (−56.67 %)



1K/1N
Severity Adjustment History
Form 15

Lab: SR	**EOT Date:** 20051203	**END Time:** 19:45	**Method:** 1K
Stand: 62	**Run Number:** 192	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Usage Dates		WDK/WDN		TGF %		Transformed TLHC %	
Start	Time	Zi	S.A.	Zi	S.A.	Zi	S.A.
20050616	11:25	-0.042	0.0	-0.248	0	0.352	0.000
20050530	20:37	-0.423	0.0	-0.191	0	0.578	0.000
20040308	03:03	-0.708	25.2	-0.198	0	0.295	0.000
20021008	13:34	-0.644	0.0	-0.361	0	0.018	0.000
20020826	12:15	-0.634	0.0	-0.316	0	0.002	0.000
20020727	14:40	-0.479	0.0	-0.104	0	-0.300	0.000
20011027	01:58	-0.271	0.0	-0.091	0	-0.238	0.000
20011014	13:38	-0.723	25.8	0.102	0	-0.253	0.000
20010818	22:43	-0.890	31.7	-0.024	0	-0.179	0.000
20001202	21:47	-0.753	26.8	0.090	0	-0.529	0.000
20000719	08:35	-0.391	0.0	0.099	0	-0.433	0.000
19990713	13:48	-0.776	0.0	0.225	0	-0.413	0.000
19990302	01:29	-0.386	0.0	0.442	0	-0.603	0.000
19980414	03:18	-0.370	0.0	0.662	-10	-0.536	0.000
19980309	21:54	-0.151	0.0	0.486	0	-0.453	0.000
19980217	00:16	-0.506	0.0	0.392	0	-0.429	0.000
19971110	19:16	-0.556	0.0	0.243	0	-0.399	0.000
19971104	04:44	-0.509	0.0	0.439	0	-0.361	0.000
19971018	06:02	-0.673	24.0	0.132	0	-0.235	0.000
19970824	19:55	-0.706	25.1	0.094	0	-0.077	0.000
19970813	04:15	-0.650	0.0	-0.177	0	0.042	0.000
19970728	08:35	-0.606	0.0	-0.186	0	-0.251	0.000
19970305	04:21	-0.343	0.0	-0.209	0	-0.176	0.000
19970302	19:11	-0.178	0.0	-0.349	0	-0.082	0.000
19970226	09:21	-0.118	0.0	-0.356	0	-0.160	0.000
19970209	18:21	-0.188	0.0	-0.215	10	0.017	0.000

Lab: SR	**EOT Date:** 20051203	**END Time:** 19:45	**Method:** 1K
Stand: 62	**Run Number:** 192	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Appendix

Caterpillar 1K Photographs

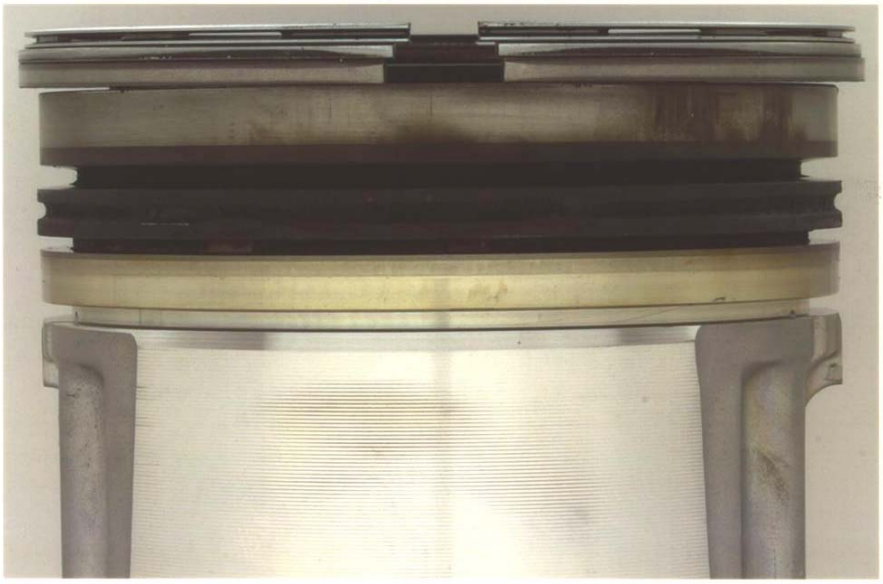
1. Piston (Thrust and Anti-Thrust)
2. Pin Bores (Front and Rear)
3. Undercrown
4. Liner (Thrust and Anti-Thrust)

Caterpillar 1K

Laboratory:	SR	**Oil Code:**	AL-26951-L		
Completion Date:	12/03/05	**Test No.:**	62-192		
Formulation / Stand Code:	N/A			**Test Hours:**	252

Piston Thrust

Piston Anti-Thrust



Caterpillar 1K

Laboratory:	SR	**Oil Code:**	AL-26951-L		
Completion Date:	12/03/05	**Test No.:**	62-192		
Formulation / Stand Code:	N/A			**Test Hours:**	252

Pinbores

Front

Rear

Caterpillar 1K

Laboratory:	SR	**Oil Code:**	AL-26951-L		
Completion Date:	12/03/05	**Test No.:**	62-192		
Formulation / Stand Code:	N/A			**Test Hours:**	252

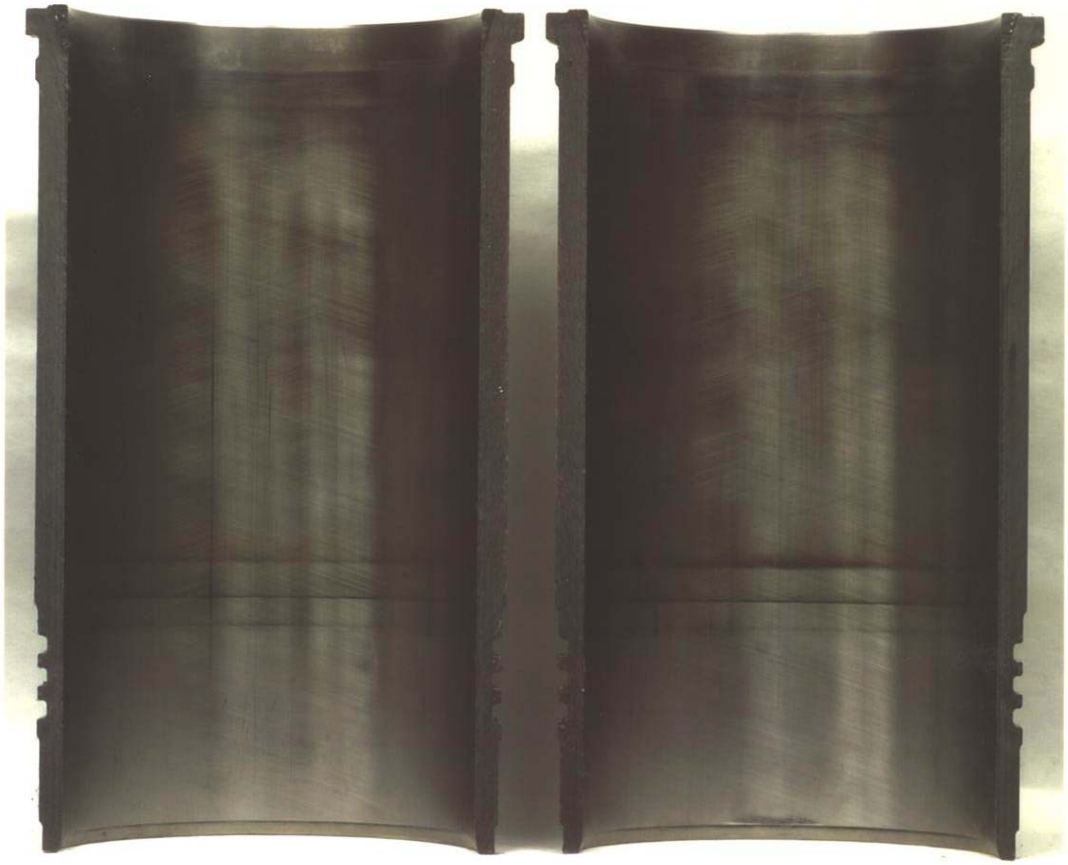
Piston Undercrown

Caterpillar 1K

Laboratory:	SR	**Oil Code:**	AL-26951-L		
Completion Date:	12/03/05	**Test No.:**	62-192		
Formulation / Stand Code:	N/A			**Test Hours:**	252

Liner

Thrust **Anti-Thrust**



APPENDIX 2

Cat 1K/1N Test Using JP-8 Fuel and QMI Fuel Additive and Army Reference Oil

1K/1N

Version 20040527

Title / Validity Declaration Page

Method 1K

Conducted for

SOUTHWEST RESEARCH INSTITUTE
ARMY LAB

N	V = Valid
	I = Invalid
	N = Results cannot be Interpreted as Respresentative of Oil Performance (Non-Reference Oil) and shall not be used for Multiple Test Acceptance Criteria

Test Number	
Test Stand: 62	**Engine Run No.:** 193
EOT Time: 07:31	**EOT Date:** 20051221
Oil Code / CMIR: * AL-26951-L	
Formulation / Stand Code: A	
Alternate Codes: B FUEL = JP-8+Q AL-27139	

In my opinion this test has not been conducted in accordance with the 1K/1N Test Procedure (Research Report RR:D02-1273/RR:D02-1321) and the appropriate amendments through the information letter system. The remarks included in the report describe the anomalies associated with this test.

The results of this report relate only to the items tested.

* *CMIR or Non-Reference Oil Code*

A *ACC -Registered Tests Only*

B *When Provided or Required by Client*

Submitted by:

Southwest Research Institute (R)
Testing Laboratory

James F. McCord
Signature

James F. McCord
Typed Name

Research Engineer
Title

1K/1N
Test Report Summary
Form 1

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193		
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L	JP-8 +Q Fuel		

Start Date: 20051210	Total Test Length: 252	TMC Oil Type:
Laboratory Internal Oil Code: LO-206830		

	Correction Effective Date	WDK / WDN	TGF %	TLHC %	Transformed TLHC %	BSOC g/k W-h	EOTOC g/kW-h
Unadjusting Lab Rating		276.1	44	0	0.000	0.21	0.20
Industry Correction (if any)							
Subtotal		276.1	44		0.000	0.21	0.20
Lab Severity Adjustment (if any)[A]	20050616	0.0	0		0.000	0.00	
Total		276.1	44	0	0.000	0.21	0.20

	Effective Date	WDK / WDN	TGF %	TLHC %	Transformed TLHC %	BSOC g/k W-h	EOTOC g/kW-h
Test Target Mean[B]							
Test Target STD[B]							
CI-4 Pass Limits (First-Test)[A,C]		332.0	24.0	4.0		0.50	

	Referee Lab	WDK / WDN	TGF %
Referee Ratings			

	Top	Int. 1	Oil	Piston	Liner
Ring Loss of Side Clearance (mm)	0.007	0.006	0.000		
Ring End Gap Increase (mm)	0.039	0.025	0.026		
Is the Ring Stuck?	NO	NO	NO		
Scuffed Area %	0	0	0	0	0
Average Wear Step (mm)					0.197
% Bore Polish					5.0

Notes:
[A] *Non-reference tests only*
[B] *Reference tests only*
[C] *See Appendix X4*

1K/1N
Operational Summary
Form 2

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Operating Condition		Minimum	Maximum	Average	Specification
Engine Speed	r/min	2094.0	2168.0	2100.0	2100 ± 10
Engine Power	kW	47.3	56.3	50.7	Report
Fuel Flow	g/min	174.4	186.0	184.9	185 ±1
Humidity	g/kg	14.9	19.2	17.5	17.8 ± 1.7
Temperature °C					
Coolant Out	°C	92.7	93.3	93.0	93 ± 2.5
Coolant In	°C	86.6	87.8	87.2	Report
Coolant delta T	°C	5.3	6.2	5.8	5 ±1.0
Oil To BRG	°C	106.8	108.9	107.0	107 ± 2.5
Oil Cooler In	°C	109.4	112.1	111.0	Report
Inlet Air	°C	126.3	128.9	127.0	127 ± 2.5
Exhaust	°C	565.6	598.3	577.6	550 ± 30
Fuel @ Injector Housing	°C	53.3	62.7	57.4	57 ± 3
Pressures					
Oil to Bearing	kPa	368.2	414.4	404.7	482 Max
Oil to Jet	kPa	328.2	364.7	358.4	360 ± 13
Inlet Air	kPa	239.4	241.1	240.1	240 ± 1
Exhaust (ABS)	kPa	215.4	217.1	216.1	216 ±1
Fuel @ Filter HSG	kPa	130.3	234.4	209.1	210 ± 20
Crankcase Vacuum	kPa	0.59	0.88	0.70	0.7 ± 0.1
Coolant Jug Pressure	kPa	32.4	87.6	37.0	Report
Flows					
Blowby	L/min	7.8	14.4	11.8	Report
Coolant Flow	L/min	59.0	71.2	64.8	65 ± 2

Air/Fuel Ratio 24 Hr:	29.0	Air/Fuel Ratio 252 Hr:	28.8

Assembly Measurement and Parts Record

Piston / Head Clearance mm:	3.531	Intake Valve Open °ATC:	3.0
		Fuel Flow Timing °BTC:	31.5

	Part No. (1)	Serial No. (2)	Date Code	Inspection Code
Liner	1Y3998	211001D1468D	N/A [F]	N/A [G]
Ring Set (1)	1Y0728		0107 [I]	4349 [H]
Piston	1Y0727	N/A	1001 (E) [D]	1171 (E) [E]

(1) and (2) Number on Parts Box Yellow Label

[D] *Number below "E" located on top of piston*
[E] *Number on top of "E" located on top of piston*
[F] *Four alphanumeric characters (NNAN) on liner O.D.*
[G] *Four digit number on liner O.D.*
[H] *Three or four digit number on white label on ring set box*
[I] *NN-NN from part number label on ring set box*

1K/1N
Operational Summary - Offset and Deviation
Form 3

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Controlled Parameter	Allowable % Out	This Test % Out	Allowable % Off	This Test % Off
Speed	5	0.2	20	0.0
Fuel Flow	10	3.4	25	4.5
Humidity	10	0.3	25	10.0
Coolant Flow	5	0.0	25	0.0
Temperature				
Coolant Out	5	0.0	20	6.4
Oil to Bearing	5	0.0	20	3.6
Intake Air	5	0.0	20	6.4
Fuel at Injector Housing	5	0.9	20	6.7
Pressures				
Oil Jet	5	0.0	25	0.4
Intake Air	10	0.0	25	0.0
Exhaust	10	0.0	25	2.4
Fuel at Filter Housing	5	1.0	20	2.9
Crankcase Vacuum	10	0.0	20	0.0

1N
Piston Rating Summary
Form 4

Test Identification	Lab: SR	EOT Date: 20051221	End Time: 07:31	Stand: 62	Run Number: 193	Method: 1K	Test Length: 252
Formulation / Stand Code:				Oil Code / CMIR: AL-26951-L			
Test Fuel: JP-8 + Add	Fuel Batch: TANK 137	Date Rated: 20051221	Rating Number:		Rater: GC		

Last Stand Reference Information	Date Completed:	Stand Number: 62	Run Number:	TMC Oil Code:

	WDK / WDN	TGF	TLHC	Transformed TLHC	BSOC	EOTOC
Last Reference This Stand						
Industry Average						
Industry Std						

Total Piston Ratings Summary

		Grooves						Lands						Upper Skirt		Under Crown		Pin Bores			
	Dep. Factor	No. 1		No. 2		No. 3		No. 1		No. 2		No. 3						Front		Rear	
		A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.	A, %	Dem.
Carbon	HC-1.0	25	25.00	5	5.00					7	7.00										
	MC-0.5	22	11.00																		
	LC-.25	53	13.25	72	18.00			36	9.00	93	23.25										
	Total	100	49.25	77	23.00	0	0.00	36	9.00	100	30.25	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Lacquer	8 - 9																				
	7 - 7.9																				
	6 - 6.9																				
	5 - 5.9			5	0.28							2	0.10								
	4 - 4.9			5	0.22			5	0.22			5	0.20								
	3 - 3.9							15	0.45												
	2 - 2.9			13	0.32	25	0.56	10	0.25			60	1.38	15	0.30	25	0.58			5	0.10
	1 - 1.9					20	0.24	34	0.34			23	0.28	30	0.39	15	0.22	5	0.08		
	>0 - 0.9					55	0.23					10	0.03								
	Clean		0		0		0		0		0		0	55	0	60	0	95	0	95	0
	Total	0	0.00	23	0.82	100	1.03	64	1.26	0	0.00	100	1.99	100	0.69	100	0.80	100	0.08	100	0.10
Rating		49.25		23.82		1.03		10.26		30.25		1.99		0.69		0.80		0.08		0.10	
WDK LOC FCT		1.5		1.5		25		1		1		25		50		20		0		0	
Ind Rating		73.88		35.73		25.75		10.26		30.25		49.75		34.50		16.00		0.00		0.00	

TGF %	Int. GR. Fill %	WDK / WDN	Unweighted Dep.	T.L. Heavy Carbon %	T.L. Flaked Carbon %	ACC GR Fill %
44	31	276.1	118.3	0	0	59

1K/1N
Rating Worksheet

Method: 1K Total Test Length: 252

Test No.: 62-193 Oil Code: AL-26951-L Rater: GC EOT Date: 20051221

Grooves

	No. 1			No. 2			No. 3			Undercrown			Upperskirt		
	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem
Carbon	25	1.0	25.00	5	1.0	5.00		1.0			1.0			1.0	
	22	.50	11.00					.50							
	53	.25	13.25	72	.25	18.00		.25			.25			.25	
	100	Sub T	49.25	77	Sub T	23.00	0	Sub T	0.00	0	Sub T	0.00	0	Sub T	0.00
Varnish		10-10.0		5	10-4.5	0.28	15	10-7.6	0.36	5	10-7.3	0.14	15	10-8.0	0.30
		10-10.0		5	10-5.5	0.22	10	10-8.0	0.20	20	10-7.8	0.44	15	10-8.4	0.24
		10-10.0		3	10-7.2	0.08	20	10-8.8	0.24	15	10-8.5	0.22	15	10-9.0	0.15
		10-10.0		10	10-7.6	0.24	15	10-9.2	0.12	60	10-10.0		55	10-10.0	
		10-10.0			10-10.0		10	10-9.5	0.05		10-10.0			10-10.0	
		10-10.0			10-10.0		30	10-9.8	0.06		10-10.0			10-10.0	
		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
	0	Sub T	0.00	23	Sub T	0.82	100	Sub T	1.03	100	Sub T	0.80	100	Sub T	0.69
		Total	49.25		Total	23.82		Total	1.03		Total	0.80		Total	0.69

Lands / Pin Bores

	No. 1			No. 2			No. 3			Front			Rear		
	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem	A%	FCT	Dem
Carbon		1.0		7	1.0	7.00		1.0			1.0			1.0	
	36	.25	9.00	93	.25	23.25		.25			.25			.25	
	36	Sub T	9.00	100	Sub T	30.25	0	Sub T	0.00	0	Sub T	0.00	0	Sub	0.00
Varnish	5	10-5.5	0.22		10-10.0		2	10-5.0	0.10	5	10-8.5	0.08	5	10-8.0	0.10
	15	10-7.0	0.45		10-10.0		5	10-6.0	0.20	95	10-10.0		95	10-10.0	
	10	10-7.5	0.25		10-10.0		15	10-7.3	0.40		10-10.0			10-10.0	
	34	10-9.0	0.34		10-10.0		20	10-7.6	0.48		10-10.0			10-10.0	
		10-10.0			10-10.0		25	10-8.0	0.50		10-10.0			10-10.0	
		10-10.0			10-10.0		13	10-8.6	0.18		10-10.0			10-10.0	
		10-10.0			10-10.0		10	10-9.0	0.10		10-10.0			10-10.0	
		10-10.0			10-10.0		10	10-9.7	0.03		10-10.0			10-10.0	
		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
		10-10.0			10-10.0			10-10.0			10-10.0			10-10.0	
	64	Sub T	1.26	0	Sub T	0.00	100	Sub T	1.99	100	Sub T	0.08	100	Sub T	0.10
		Total	10.26		Total	30.25		Total	1.99		Total	0.08		Total	0.10

	Grooves			Lands			Upper Skirt	Under Crown	Pin Bores	
	1	2	3	1	2	3			Front	Rear
Rating	49.25	23.82	1.03	10.26	30.25	1.99	0.69	0.80	0.08	0.10
WDK LOC FCT	1.5	1.5	25	1	1	25	50	20	0	0
WT Rating	73.88	35.73	25.75	10.26	30.25	49.75	34.50	16.00	0.00	0.00

TGF: 44 Intermidate Groove Fill: 31 WDK / WDN: 276.1 Top Land Heavy Carbon: 0

1K/1N

Supplemental Piston Deposits (Groove Sides and Rings)

Form 5

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Deposit Type			Carbon			Varnish									
			HC	MC	LC	8 - 9	7 - 7.9	6 - 6.9	5 - 5.9	4 - 4.9	3 - 3.9	2 - 2.9	1 - 1.9	>0 - 0.9	Clean
Groove Top and Bottom	1	T			70	30									
		B					20	10			50	10		10	
	2	T		30	55								15		
		B				20				65				15	
	3	T								20	30	30	20		
		B									20	10	10	60	
Top Bottom and Back of Rings	1	T			10	5			15	40	15		10	5	
		B								5	15			80	
		BK	20	5	70							5			
	2	T	3	3	9						20	30	20	15	
		B									20	60	10	10	
		BK			30	30						40			
	3	T									40	30		30	
		B									10	40		50	
		BK									10	90			

Additional Deposit & Condition Ratings	
Piston Crown	NORMAL
Liner	NORMAL
Rings	NORMAL

1K/1N
Oil Analysis and Results Summary
Form 6

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			
Test Method: 1K	**Test Fuel:** JP-8 + Add	**Fuel Batch:** TANK 137	

Oil Analysis / Engine Hours	NEW / 0	24	204	252
Viscosity @ 100°C	15.06	13.70	14.09	14.29
TBN D4739	6.82	5.82	2.88	2.66

Wear Metals:									
	Fe / Al	4	<1	8	2	23	2	27	2
	Si / Cu	4	<1	6	<1	6	2	6	2
	Cr / Pb	<1	<1	<1	1	<1	1	<1	<1
Fuel Dilution %				0.3		0.3		0.3	
Blowby (L/min)				10.8		12.2		12.9	

24 Hour Average BSOC (g/w-W-h) for Hours End | 0-252 Hr. Avg. BSOC (g/k-W-h): 0.21 | EOT Oil Consumption(g/kW-h): 0.20

24	48	72	108	132	156	180	204	228	252
0.27	0.23	0.18	0.28	0.21	0.21	0.21	0.22	0.23	0.17

Inspection and Measurement Summary	**Ring Gap Increase (mm)**	**Side Clearance Loss (mm)**	**Ring Stuck (1)**	**Scuffed Area % (2)**	**% Bore Polish (With Grid)**	**Average Wear Step (mm)**
Top Ring	0.039	0.007	NO	0		
Intermediate Ring	0.025	0.006	NO	0		
Oil Ring	0.026	0.000	NO	0		
Piston				0		
Cylinder Liner				0	5.0	0.197

Piston Deposit Summary	TGF %	Int. Gr. F.%	WDK	Un Wt Dep	T.L. Heavy Carbon	T.L. Flaked Carbon %
	44	31	276.1	118.3	0	0

Unweighted Piston Deposits

Grooves			**Lands**			**Upper Skirt**	**Under Crown**	**Pin Bores**	
1	2	3	1	2	3			Front	Rear
49.25	23.82	1.03	10.26	30.25	1.99	0.69	0.80	0.08	0.10

1K/1N
Unscheduled Downtime & Maintenance Summary
Form 7

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Number of Downtime Occurrences: 4

Test	Date	Downtime	Reasons
126:32	20051215	1:51	Replaced exhaust temp thermocouple.
139:11	20051216	4:00	Replaced coolant temp thermocouple wire.
141:25	20051216	3:30	Power failure.
251:01	20051221	1:42	Replaced fuel filter.
Total Downtime		011:03	

Other Comments

Number of Comment Lines: 0

1K/1N
Ring Measurements
Form 8

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Ring Gaps (mm)	Top	Intermediate	OIL
Specifications	0.724 ± 0.076 mm	0.673 ± 0.076 mm	0.572 ± 0.190 mm
Pre-Test	0.698	0.673	0.571
Post-Test	0.737	0.698	0.597
Increase	0.039	0.025	0.026

Ring Side Clearance *		A	B	C	D	Average	Minimum	Specification
Top	Pre-Test	0.165	0.165	0.165	0.165	0.165	0.165	0.193±0.032 mm
	Post-Test	0.152	0.152	0.165	0.165	0.158	0.152	
	LSC	0.013	0.013	0.000	0.000	0.007	0.000	
Intermediate	Pre-Test	0.076	0.076	0.076	0.076	0.076	0.076	0.090±0.020 mm
	Post-Test	0.076	0.076	0.064	0.064	0.070	0.064	
	LSC	0.000	0.000	0.012	0.012	0.006	0.000	
Oil	Pre-Test	0.064	0.064	0.064	0.064	0.064	0.064	0.073 ±0.016 mm
	Post-Test	0.064	0.064	0.064	0.064	0.064	0.064	
	LSC	0.000	0.000	0.000	0.000	0.000	0.000	

* Notes:

1. Write "Stuck" In Place of Dimension When Applicable.

2. Write "<0.038 mm" For Clearance When Applicable.

3. Write ">" Before Calculated Decrease or Average Decrease Values That Incorporate a "<0.038 mm" in Calculation.

4 LSC: Loss of Clearance.

5. Minimum: Intermediate and Oil Ring Minimum Side Clearance is Measured 360° Around Piston.

1K/1N
Liner Measurements
Form 9

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Liner Surface Finish (micrometer)			
Distance From Top	**Transverse**	**Longitudinal**	**Average**
130 mm	0.44	0.37	0.40
50 mm	0.39	0.50	0.44
25 mm	0.47	0.44	0.45
		Total Average:	0.43

% Liner Bore Polish - Grid (Add T/AT Values From Grid)	
Thrust	3.0
Anti-Thrust	2.0
Total	5.0

Liner Bore Measurement (mm)		
Before Test - Diameter (Dial Bore Gage)		
Bore Height	**Longitudinal**	**Transverse**
230 mm	137.180	137.155
130 mm	137.168	137.175
50 mm	137.163	137.193
25 mm	137.160	137.201
15 mm	137.190	137.163

After Test - (Surface Profile)				
	Longitudinal		**Transverse**	
	Front	Rear	T	AT
Wear Step @ 15mm	0.203	0.203	0.178	0.203

1K/1N

Characteristics of the Data Acquisition System

Form 10

Lab: SR	EOT Date: 20051221	END Time: 07:31	Method: 1K
Stand: 62	Run Number: 193	Total Test Length: 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Parameter (1)	Sensing Device (2)	Calibration Frequency (3)	Record Device (4)	Observation Frequency (5)	Record Frequency (6)	Log Frequency (7)	System Response (8)
Operation Conditions							
Engine Speed (r/min)	Magnetic Pickup	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.1
Engine Power (kW)	Load Cell	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	1.9
Fuel Flow (kJ/min)	Micro-Motion	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	70.3
Humidity (g/kg)	Dew Cell	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	6.0 min
Temperatures (°C)							
Coolant Out	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.8
Coolant In	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.7
Oil to Bearing	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.9
Oil Cooler In	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	3.0
Inlet Air	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.8
Exhaust	Thermocouple	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.9
Pressure (kPa)							
Oil to Bearing	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.9
Oil to Jet	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.0
Inlet Air	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	1.0
Exhaust	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	3.0
Fuel @ Filter HSG	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	2.8
Crankcase Vacuum	Strain-gage	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	3.0
Flows (L/min)							
Blowby	Gas Meter	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	10.0
Coolant Flow	Barco Venturi	Every 5 Tests	HP 1000 Computer	Every Second	Every Minute	Every Minute	3.0

Legend:

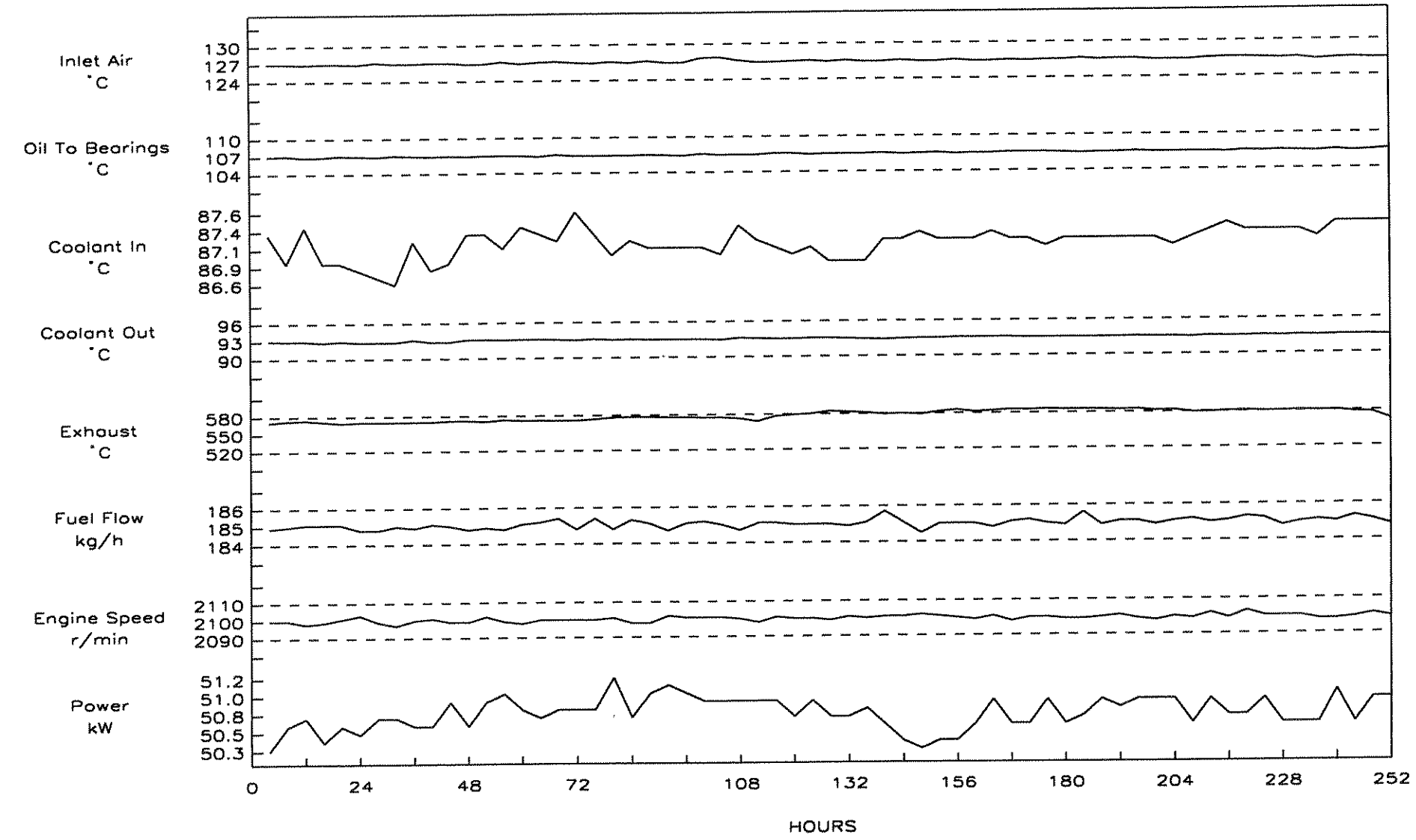
(1) Operating Parameter
(2) The Type of Device Used to Measure Temperature, Pressure, or Flow
(3) Frequency at Which the Measurement System is Calibrated
(4) The Type of Device Where Data is Recorded
- LG - Hanglog Sheet
- DL - Automatic Data Logger
- SC - Strip Chart Recorder
- C/M - Computer, Using Manual Data Entry
- C/D - Computer, Using Direct I/O Entry

(5) Data Area Observed but Only Recorded if off Spec.
(6) Data are Recorded but are not Retained at EOT
(7) Data are Logged as Permanent Record, Note Specify if:
- SS - Snapshot Taken at Specified Frequency
- AG/X - Average of X Data Points at Specified Frequency

(8) Time for the Output to Reach 63.2% of Final Value for Step Change at Input

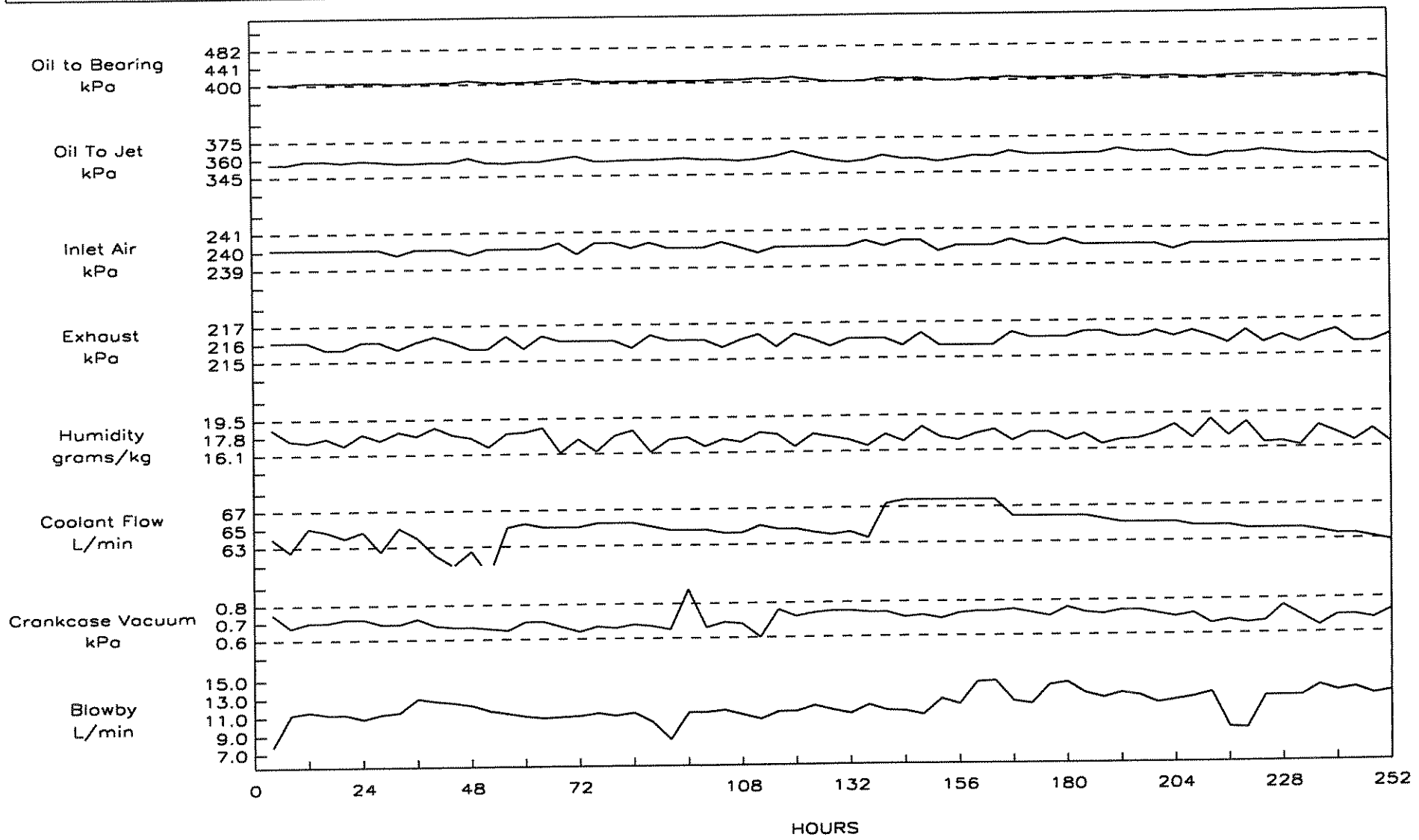
1K/1N
FORM 11

LAB: SR	EOT DATE: 20051221	END TIME: 07:31	METHOD: 1K
STAND: 62	RUN NUMBER: 193		
FORMULATION/STAND CODE:			
OIL CODE/CMIR: AL-26951-L			



1K/1N
FORM 12

LAB: SR	EOT DATE: 20051221	END TIME: 07:31	METHOD: 1K
STAND: 62	RUN NUMBER: 193		
FORMULATION/STAND CODE:			
OIL CODE/CMIR: AL-26951-L			



1K/1N
FORM 13
OIL CONSUMPTION PLOT

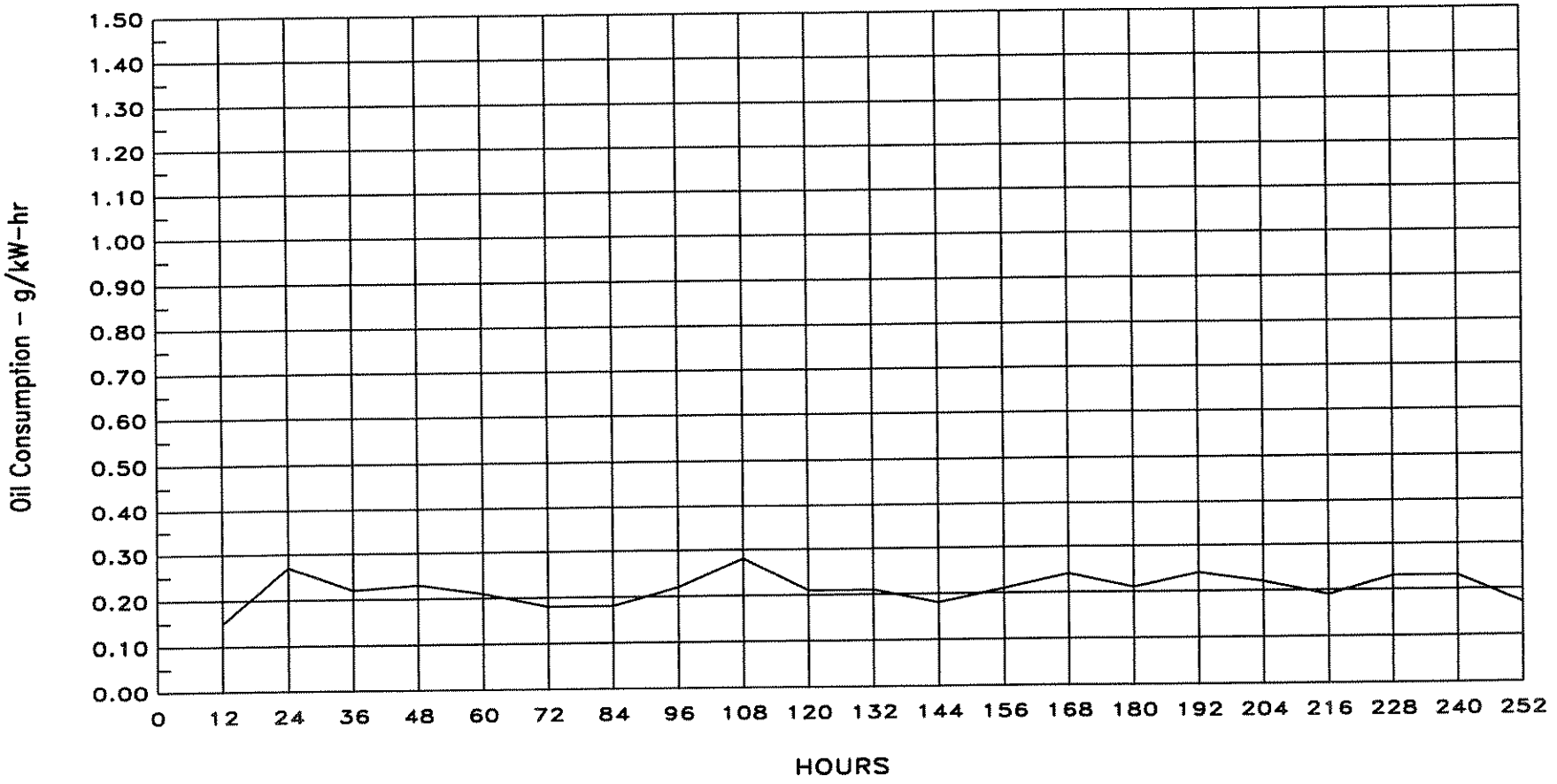
LAB: SR	EOT DATE: 20051221	END TIME: 07:31	METHOD: 1K
STAND: 62	RUN NUMBER: 193		
FORMULATION/STAND CODE:			
OIL CODE/CMIR: AL-26951-L			

0 - 24 Hour 0.21

228 - 252 Hour 0.20

Avg 0 - 252 Hour 0.21

Increase 0 - 24 to 228 - 252 Hour -0.10 (-37.04 %)



1K/1N
Severity Adjustment History
Form 15

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Usage Dates		WDK/WDN		TGF %		Transformed TLHC %	
Start	Time	Zi	S.A.	Zi	S.A.	Zi	S.A.
20050616	11:25	-0.042	0.0	-0.248	0	0.352	0.000
20050530	20:37	-0.423	0.0	-0.191	0	0.578	0.000
20040308	03:03	-0.708	25.2	-0.198	0	0.295	0.000
20021008	13:34	-0.644	0.0	-0.361	0	0.018	0.000
20020826	12:15	-0.634	0.0	-0.316	0	0.002	0.000
20020727	14:40	-0.479	0.0	-0.104	0	-0.300	0.000
20011027	01:58	-0.271	0.0	-0.091	0	-0.238	0.000
20011014	13:38	-0.723	25.8	0.102	0	-0.253	0.000
20010818	22:43	-0.890	31.7	-0.024	0	-0.179	0.000
20001202	21:47	-0.753	26.8	0.090	0	-0.529	0.000
20000719	08:35	-0.391	0.0	0.099	0	-0.433	0.000
19990713	13:48	-0.776	0.0	0.225	0	-0.413	0.000
19990302	01:29	-0.386	0.0	0.442	0	-0.603	0.000
19980414	03:18	-0.370	0.0	0.662	-10	-0.536	0.000
19980309	21:54	-0.151	0.0	0.486	0	-0.453	0.000
19980217	00:16	-0.506	0.0	0.392	0	-0.429	0.000
19971110	19:16	-0.556	0.0	0.243	0	-0.399	0.000
19971104	04:44	-0.509	0.0	0.439	0	-0.361	0.000
19971018	06:02	-0.673	24.0	0.132	0	-0.235	0.000
19970824	19:55	-0.706	25.1	0.094	0	-0.077	0.000
19970813	04:15	-0.650	0.0	-0.177	0	0.042	0.000
19970728	08:35	-0.606	0.0	-0.186	0	-0.251	0.000
19970305	04:21	-0.343	0.0	-0.209	0	-0.176	0.000
19970302	19:11	-0.178	0.0	-0.349	0	-0.082	0.000
19970226	09:21	-0.118	0.0	-0.356	0	-0.160	0.000
19970209	18:21	-0.188	0.0	-0.215	10	0.017	0.000

Lab: SR	**EOT Date:** 20051221	**END Time:** 07:31	**Method:** 1K
Stand: 62	**Run Number:** 193	**Total Test Length:** 252	
Formulation / Stand Code:			
Oil Code / CMIR: AL-26951-L			

Appendix

Caterpillar 1K Photographs

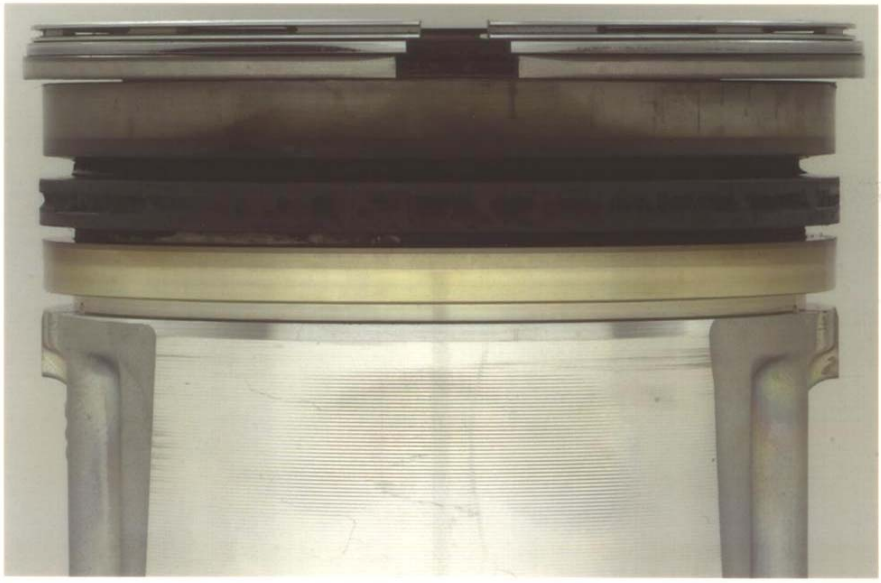
1. Piston (Thrust and Anti-Thrust)
2. Pin Bores (Front and Rear)
3. Undercrown
4. Liner (Thrust and Anti-Thrust)

Caterpillar 1K

Laboratory:	SR	**Oil Code:**	AL-26951-L	
Completion Date:	12/21/05	**Test No.:**	62-193	
Formulation / Stand Code:				**Test Hours:** 252

Piston Thrust

Piston Anti-Thrust



Caterpillar 1K

Laboratory:	SR	**Oil Code:**	AL-26951-L		
Completion Date:	12/21/05	**Test No.:**	62-193		
Formulation / Stand Code:				**Test Hours:**	252

Pinbores

Rear

Caterpillar 1K

Laboratory:	SR	**Oil Code:**	AL-26951-L	
Completion Date:	12/21/05	**Test No.:**	62-193	
Formulation / Stand Code:				**Test Hours:** 252

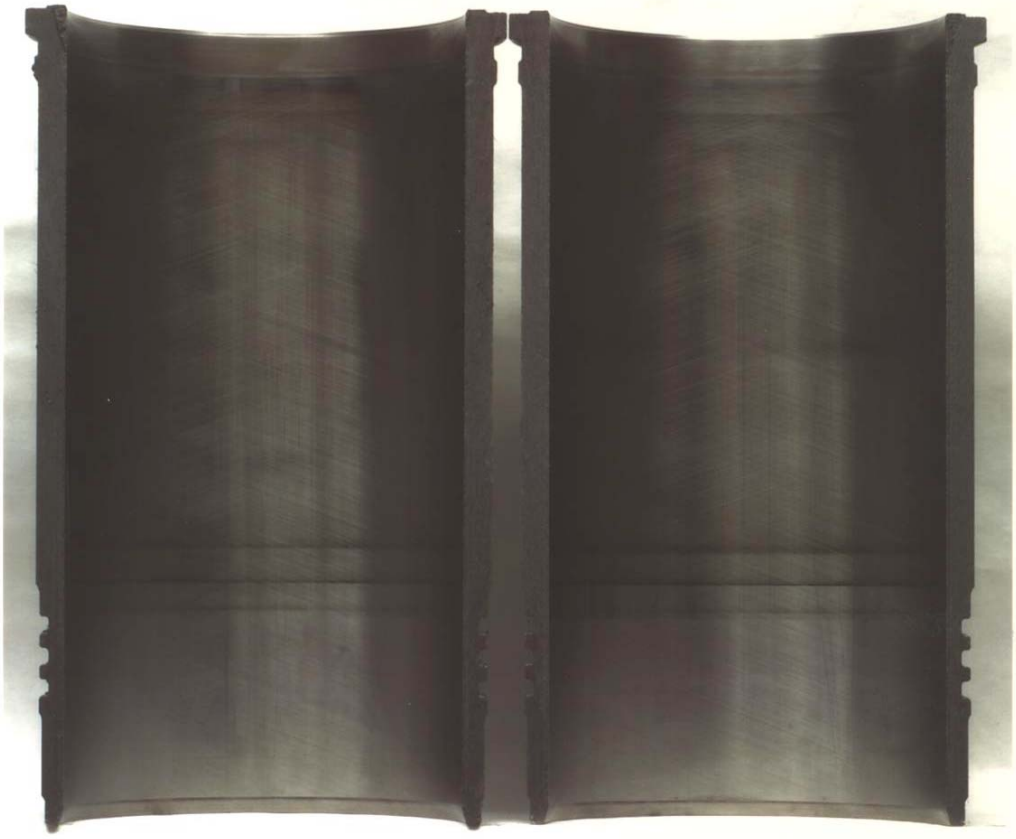
Piston Undercrown

Caterpillar 1K

Laboratory:	SR	**Oil Code:**	AL-26951-L	
Completion Date:	12/21/05	**Test No.:**	62-193	
Formulation / Stand Code:				**Test Hours:** 252

Liner

Thrust **Anti-Thrust**



APPENDIX 3

Diesel Fuel Effects on Fuel Economy and Exhaust Emissions Report

SOUTHWEST RESEARCH INSTITUTE®

6220 CULEBRA ROAD • POST OFFICE DRAWER 28510 • SAN ANTONIO, TEXAS, USA 78228-0510 • (210) 684-5111 • WWW.SWRI.ORG
HTTP://ENGINEANDVEHICLE .SWRI.ORG

ENGINE, EMISSIONS, AND VEHICLE RESEARCH DIVISION
FAX: (210) 522-3950

ISO 9001 CERTIFIED
ISO 14001 Certified

March 15, 2006

Edwin Frame
U.S. Army TARDEC
6220 Culebra Rd.
San Antonio TX 78238
eframe@swri.org

Subject: Final Letter Report, "Diesel Fuel Effects on Fuel Economy and Exhaust Emissions", SwRI Project 03.03227.36.202

Dear Mr. Frame:

This report contains the results of the evaluation of two fuels for fuel economy and exhaust emission effects. The two fuels were evaluated by operating a Chevrolet Silverado diesel pickup truck over the chassis dynamometer portion of the Federal Test Procedure (FTP-75) and the Highway Fuel Economy Test (HwFET). This project was performed for the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) by the Department of Engine and Emissions Research (DEER), Engine, Emissions & Research Division, Southwest Research Institute® (SwRI®). Testing was carried out during January 2006. Mr. Edwin Frame was the program monitor for this program. The SwRI project leader was Mr. Eugene Jimenez. Testing was conducted under the supervision of Mr. Bill Olson.

1.0 TECHNICAL APPROACH

The objective of this project was to determine the fuel economy and exhaust emission effects of two diesel fuels. The fuels were evaluated in a 2006 Chevrolet Silverado diesel pickup truck operating on a chassis dynamometer over the FTP-75 and an HwFET driving cycles in a manner consistent with the Code of Federal Regulations (CFR), Title 40, Part 86 and 600. Details of the test program are given below.

1.1 Test Fuels

The TARDEC provided DEER with an additized and an unadditzed diesel fuel for testing. The specifications of each fuel are provided in Appendix A. When changing fuels in the vehicle between test sequences, a double flush procedure was followed in order to minimize the carryover of one fuel to the next. The flush procedure is shown in Appendix B.

1.2 Test Vehicle

The vehicle used for this project was a 2006 C2500 Chevrolet Silverado equipped with a Duramax diesel engine. The vehicle was acquired by SwRI from a local rental agency and had approximately 10,000 miles on the odometer at the start of testing. Specifications of the test vehicle are provided in Appendix C.

1.3 Test Sequence

An initial fuel flush procedure, as mentioned in Section 1.1, was performed with the unadditized fuel. Prior to the evaluation of each fuel, the test vehicle was preconditioned with a single cold-start FTP-75 + HwFET test sequence. The unadditized fuel was tested first over five replicate FTP-75 + HwFETs. Another fuel flush procedure was then performed to install the additized fuel, which was tested over six FTP-75 + HwFETs. Two tests were void due to equipment failure and human error, respectively. One test resulted in a questionable particulate measurement, so an addition test was performed. A total of six valid tests were completed on the unadditized fuel. The test program was conducted as shown in Table 1.

TABLE 1. TEST SEQUENCE

Step	Description
1.	Receive test fuels from U.S. Army Lab
2.	Procure a Chevrolet Silverado diesel pick-up from a local rental fleet
3.	Conduct chassis dyno setup for the vehicle
4.	Flush and filled vehicle with unadditized fuel
5.	Soak vehicle overnight
6.	Precondition vehicle with cold-start FTP-75 + HwFET cycle
7.	Soak vehicle overnight
8.	Conduct a cold-start FTP-75 and HwFET test
9.	Repeat Steps 7 and 8 four more times
10.	Repeat Steps 4 through 8 with the additized fuel
11.	Repeat Steps 7 and 8 due to questionable PM measurment

1.4 Exhaust Emissions

Gaseous total hydrocarbons (THC), carbon monoxide (CO), oxides of nitrogen (NO_X), carbon dioxide (CO_2) and particulate matter (PM) exhaust emission rates were determined in a manner consistent with EPA protocals for light-duty emissions testing as given in the Code of Federal Regulations Title 40, Parts 86. A constant volume sampler was used to collect proportional dilute exhaust in Tedlar bags for analysis of CO and CO_2. THC and NO_X were measured continuously from the dilution tunnel. Concurrently, a proportional sample of the dilute exhaust was drawn through Pallflex TX40 Teflon-coated glass fiber filters for gravimetric determination of the mass emissions of PM. Exhaust constituents were determined as specified below:

CONSTITUENT	ANALYSIS METHOD
Total Hydrocarbon	Heated Flame Ionization
Carbon Monoxide	Non-Dispersive Infrared
Carbon Dioxide	Non-Dispersive Infrared
Oxides of Nitrogen	Chemiluminescence
Particulate Matter	Gravimetric Method

Fuel economy was determined using the EPA-specified carbon balance method in a manner consistent with CFR, Title 40, Parts 86 and 600. Fuel economy was calculated for both the FTP-75 and HwFET. A composite fuel economy value was then calculated based on a weighted average of the FTP-75 and HwFET fuel economy values as follows:

$$Composite\ Fuel\ Economy = \frac{1}{(\frac{0.55}{FE_{FTP-75}}) + (\frac{0.45}{FE_{HwFET}})}$$

1.5 Chassis Dynamometer Setup

The Chevrolet Silverado was tested on a Horiba 48-inch single-roll chassis dynamometer. This dynamometer electrically simulates inertia weights up to 15,000 lb over the FTP-75 and HwFET, and provides programmable road load simulation of up to 200 hp continuous at 65 mph. Chassis dynamometer coefficients and equivalent test weight was taken from EPA's Certification Test Results Reports. The dynamometer settings for the Silverado are given in Table 2.

TABLE 2. Dynamometer Load Settings

a coefficient	79.03 lbs
b coefficient	0.1046 lb/mph
c coefficient	0.04876 lb/mph^2
Equivalent Test Weight	7500 lbs

2.0 TEST RESULTS

The average FTP-75, HwFET, and composite fuel economy results are shown in Table 3. Detailed results along with standard deviation and coefficient of variation are given in Appendix D. The additized fuel resulted in fuel economy improvements over both FTP-75 and HwFET test cycles. Using the Student's T-test with a 99 percent confidence interval, statistically significant improvements of 1.7 and 1.6 percent were observed for the FTP-75 and the calculated composite fuel economies, respectively.

TABLE 3. FUEL ECONOMY RESULTS

Test		FTP-75 (mi/gal)	HwFET (mi/gal)	Composite (mi/gal)
Unadditized Fuel	**Test 1**	13.16	19.52	15.42
	Test 2	13.13	19.63	15.43
	Test 3	13.09	19.42	15.34
	Test 4	13.15	19.21	15.33
	Test 5	12.97	19.49	15.27
	Average	13.10	19.45	15.36
Additized Fuel	**Test 1**	13.17	19.90	15.53
	Test 2	Void		
	Test 3	Void		
	Test 4	13.30	19.70	15.58
	Test 5	13.25	19.41	15.46
	Test 6	13.27	19.62	15.53
	Test 7	13.41	19.75	15.67
	Test 8	13.55	20.06	15.87
	Average	13.33	19.74	15.61
% Change from Unadditized to Additized		1.72%	1.47%	1.63%
Statistically significant at 95 percent CI [a]		YES	YES	YES
Statistically significant at 99 percent CI [b]		YES	NO	YES
a - Based on Student's t-test with a 95 percent confidence interval b - Based on Student's t-test with a 99 percent confidence interval				

Results of THC, CO, NO_X and PM exhaust emission measurements are shown in Table 4 for both the FTP-75 and HwFET cycles. Calculated average, standard deviation, and coefficient of variation of the exhaust emissions results are given in Appendix E. Statistically significant improvements of 11 percent for THC and 6 percent for CO were observed with the additized fuel over the FTP-75 cycle. Over the HwFET cycle, the additized fuel provided a statistically significant improvement in THC of approximately 7 percent. Test printouts for the unadditized and additized fuels are shown in Appendices F and G, respectively.

Without confirming these results on additional vehicles, it is not known whether the observed changes in fuel economy and exhaust emissions were a direct result of the additized fuel, or due to some other change in operation of the test vehicle.

TABLE 4. EXHAUST EMISSIONS RESULTS

Test No.		Weighted FTP-75				Weighted HwFET			
		THC g/mi	CO g/mi	NO_X g/mi	PM mg/mi	THC g/mi	CO g/mi	NO_X g/mi	PM mg/mi
Unadditized Fuel	Test 1	0.447	1.936	6.004	109.8	0.247	0.795	4.612	62.3
	Test 2	0.474	1.933	6.074	107.9	0.243	0.785	4.632	63.2
	Test 3	0.521	2.023	6.251	110.9	0.251	0.794	4.736	72.8
	Test 4	0.473	1.985	6.123	120.6	0.243	0.788	4.539	71.1
	Test 5	0.479	1.934	5.989	120.5	0.242	0.767	4.555	72.0
	Average	0.479	1.962	6.088	113.9	0.245	0.786	4.615	68.28
Additized Fuel	Test 1	0.537	2.146	6.191	108.2	0.265	0.801	4.530	49.6
	Test 2	Void							
	Test 3	Void							
	Test 4	0.520	2.030	5.978	107.6	0.248	0.782	4.574	68.9
	Test 5	0.536	2.100	6.275	99.2	0.272	0.805	4.665	68.6
	Test 6	0.524	2.017	6.136	108.2	0.264	0.800	4.612	69.8
	Test 7	0.539	2.111	5.713	138.6	0.266	0.806	4.619	68.8
	Test 8	0.543	2.061	6.008	133.1	0.257	0.825	4.495	66.7
	Average	0.533	2.078	6.050	115.8	0.262	0.803	4.583	65.40
Percent change from Unadditized to Additized Fuel		11.4%	5.9%	-0.6%	1.6%	6.9%	2.2%	-0.7%	-4.2%
Statistically significant at 95 percent CI [a]		YES	YES	NO	NO	YES	NO	NO	NO
Statistically significant at 99 percent CI [b]		YES	YES	NO	NO	YES	NO	NO	NO

a – Based on Student's t-test with 95 percent confidence interval
b - Based on Student's t-test with 99 percent confidence interval

3.0 CLOSURE

With the submission of this report, SwRI has completed all efforts under Project No. 03227.36.202. If you have any questions please contact Gene Jimenez at (210) 522-5419 or by e-mail at ejimenez@swri.org. SwRI appreciates the opportunity to perform this study, and looks forward to meeting the future emissions research needs of the U.S. Army TARDEC.

Prepared by:

Eugene Jimenez
Research Assistant
Department of Engine and
Emissions Research

Reviewed by:

Kevin A. Whitney
Manager, Light-Duty Vehicle Emissions
Department of Engine and
Emissions Research

Approved by:

Jeff J. White
Director of Development
Department of Engine and Emissions

/lfv

APPENDIX A

TEST FUEL ANALYLSIS

TABLE A-1. TEST FUEL ANALYSIS

	Unadditized Fuel: AL-27125	Additized Fuel: AL-27132
Carbon fraction	85.45	85.14
Hydrogen fraction	13.56	13.60
Oxygen fraction	0.99	1.26
Density	0.8196 kg/L	0.8196 kg/L
Net Heating Value	18,431 Btu/lb	18,417 Btu/lb

APPENDIX B

FUEL FLUSH PROCEDURE

Candidate Fuel Change

Client: Ed Frame
Project Number: 03227.36.202
Vehicle Number: 3254
Vehicle: 2005 GMC C2500

Project Leader: E. Jimenez
Date: 1/16/06
Fuel: Candidate AL-27132-F

Technician will check and initial step by step

- ☐ ___ Drain fuel using the modified fuel system
- ☐ ___ Add 2 gallons of diesel fuel AL-27132-F
- ☐ ___ Idle engine for 5 minutes
- ☐ ___ Drain fuel using the modified fuel system
- ☐ ___ Add 2 gallons of diesel fuel AL-27132-F
- ☐ ___ Idle engine for 5 minutes
- ☐ ___ Drain fuel tank using the modified fuel system
- ☐ ___ Fill fuel tank with diesel fuel AL-27132-F

Completed by: _____

Date completed: _____

APPENDIX C

TEST VEHICLE INFORMATION

RECEIPT OF VEHICLE

TEST VEHICLE INFORMATION	
Project Number: 03.227.36.202	Vehicle #: 3254
SwRI Rep: G. Jimenez	Date: 1-3-06

VEHICLE DESCRIPTION

Year 2006 Make Chevy Model Silverado Color Tan
VIN 1GCHK23236F123254 Lic. No. 715ZC2 State TX
Engine Family 6GMXH06.6590 Evap. Family _____ Odometer 10048
No. of Cylinders 8 Displacement 6.6L AC (YES) (NO) Trans. Type Auto 4
Tire Size LT245/75R16 Bridgestone Comments 4DR 4X4

Fuel System: ☐ Gasoline ☑ Diesel ☐ Methanol ☐ Ethanol ☐ CNG ☐ LPG ☐ Dual Fuel ☐ _____

Fuel System Type: ☐ CARB ☐ TBI ☑ MPI ☐ _____

ACCESSORIES

Receiver Hitch
Bed Mat
Tailgate Cap

Test Info.
Inertia Wt: _____ Actual H.P.: _____ Fuel Code: _____ Fuel Type: Diesel

RECEIPT OF VEHICLE

VEHICLE OWNER

Name: _____ Telephone (___) _____

Address: _____

City: _____ State: _____ Zip Code: _____

Owner allows SwRI to perform exhaust emission testing on vehicle noted above.

_____

AS RECEIVED

Exterior Damage: Nothing significant noticed

Interior Damage: None

	Components				Fluid Level	
Engine Operation:	☑ Good	☐ Fair	☐ Poor	Oil:	☑ OK	☐ Low
Brakes:	☑	☐	☐	Trans.:	☑	☐
Emergency Brake:	☑	☐	☐	Radiator:	☑	☐
Horn:	☑	☐	☐	Brake:	☑	☐
Lights:	☑	☐	☐	Battery:	☑	☐
Wipers:	☑	☐	☐	Steering:	☑	☐
Exhaust:	☑	☐	☐	Clutch:	☑ NA	☑
Tires:	☑	☐	☐			

Comments: _____

_____

Note: Document all significant problems with pictures.

SIGNATURES

SwRI Rep: _____ Date: 1-3-06

Vehicle Owner or Rep: _____ Date: _____

APPENDIX D

FUEL ECONOMY RESULTS

TABLE D-1. FUEL ECONOMY SUMMARY RESULTS

Test		FTP (mi/gal)	HwFET (mi/gal)	Composite (mi/gal)
Unadditized Fuel	Test 1	13.16	19.52	15.42
	Test 2	13.13	19.63	15.43
	Test 3	13.09	19.42	15.34
	Test 4	13.15	19.21	15.33
	Test 5	12.97	19.49	15.27
	Average	13.10	19.45	15.36
	Standard Deviation	0.077	0.156	0.068
	Coefficient of Variation	0.59%	0.80%	0.44%
Additized Fuel	Test 1	13.17	19.9	15.53
	Test 2	Void		
	Test 3	Void		
	Test 4	13.30	19.7	15.58
	Test 5	13.25	19.41	15.46
	Test 6	13.27	19.62	15.53
	Test 7	13.41	19.75	15.67
	Test 8	13.55	20.06	15.87
	Average	13.33	19.74	15.61
	Standard Deviation	0.135	0.225	0.146
	Coefficient of Variation	1.01%	1.14%	0.93%
% Change from Unadditized to Additized		1.72%	1.47%	1.63%
Statistically Significant at 95 percent CI [a]		YES	YES	YES
Statistically Significant at 99 percent CI [b]		YES	NO	YES

a - Based on Student's t-test with a 95 percent confidence interval
b - Based on Student's t-test with a 99 percent confidence interval

APPENDIX E

EXHAUST EMISSION RESULTS

TABLE E-1. EXHAUST EMISSIONS SUMMARY RESULTS

Test No.		Weighted FTP-75				Weighted HwFET			
		THC g/mi	CO g/mi	NO_X g/mi	PM mg/mi	THC g/mi	CO g/mi	NO_X g/mi	PM mg/mi
Unadditized Fuel	**Test 1**	0.447	1.936	6.004	109.8	0.247	0.795	4.612	62.3
	Test 2	0.474	1.933	6.074	107.9	0.243	0.785	4.632	63.2
	Test 3	0.521	2.023	6.251	110.9	0.251	0.794	4.736	72.8
	Test 4	0.473	1.985	6.123	120.6	0.243	0.788	4.539	71.1
	Test 5	0.479	1.934	5.989	120.5	0.242	0.767	4.555	72.0
	Average	0.479	1.962	6.088	113.9	0.245	0.786	4.615	68.28
Additized Fuel	**Test 1**	0.537	2.146	6.191	108.2	0.265	0.801	4.530	49.6
	Test 2	Void							
	Test 3	Void							
	Test 4	0.520	2.030	5.978	107.6	0.248	0.782	4.574	68.9
	Test 5	0.536	2.100	6.275	99.2	0.272	0.805	4.665	68.6
	Test 6	0.524	2.017	6.136	108.2	0.264	0.800	4.612	69.8
	Test 7	0.539	2.111	5.713	138.6	0.266	0.806	4.619	68.8
	Test 8	0.543	2.061	6.008	133.1	0.257	0.825	4.495	66.7
	Average	0.533	2.078	6.050	115.8	0.262	0.803	4.583	65.40
Percent change from Unadditized to Additized Fuel		11.4%	5.9%	-0.6%	1.6%	6.9%	2.2%	-0.7%	-4.2%
Statistically significant at 95 percent CI [a]		YES	YES	NO	NO	YES	NO	NO	NO
Statistically significant at 99 percent CI [b]		YES	YES	NO	NO	YES	NO	NO	NO

a – Based on Student's t-test with 95 percent confidence interval
b - Based on Student's t-test with 99 percent confidence interval

APPENDIX F

UNADDITIZED FUEL TEST PRINTOUTS

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254 BASE T1	DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/10/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .854 O .010 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10081 MILES (16220 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.47 IN HG (748.5 MM HG) DRY BULB TEMPERATURE 69.0°F (20.6°C) NOX HUMIDITY C.F. .914

RELATIVE HUMIDITY 51.1 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	503.4	867.1	505.7
DRY/WET CORRECTION FACTOR, SAMP/BACK	.981/.987	.984/.987	.982/.987
MEASURED DISTANCE MILES (KM)	3.57 (5.75)	3.86 (6.22)	3.57 (5.74)
BLOWER FLOW RATE SCFM (SCMM)	1068.8 (30.27)	1052.3 (29.80)	1052.6 (29.81)
GAS METER FLOW RATE SCFM (SCMM)	.88 (.02)	.93 (.03)	.89 (.03)
TOTAL FLOW SCF (SCM)	8975. (254.2)	15221. (431.1)	8879. (251.5)
HC SAMPLE METER/RANGE/PPM (CONT)	12.0/ 9/ 12.00	11.9/ 9/ 11.93	13.0/ 9/ 13.02
HC BCKGRD METER/RANGE/PPM	3.8/ 2/ 3.91	3.9/ 2/ 4.01	3.9/ 2/ 4.01
CO SAMPLE METER/RANGE/PPM	30.8/ 12/ 29.68	17.2/ 12/ 16.52	17.5/ 12/ 16.81
CO BCKGRD METER/RANGE/PPM	.3/ 12/ .29	.1/ 12/ .10	.1/ 12/ .10
CO2 SAMPLE METER/RANGE/PCT	74.1/ 11/ .6370	54.5/ 11/ .4073	68.2/ 11/ .5612
CO2 BCKGRD METER/RANGE/PCT	7.4/ 11/ .0417	7.4/ 11/ .0417	7.5/ 11/ .0423
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	45.3/ 9/ 45.29	33.4/ 9/ 33.43	43.5/ 9/ 43.49
NOX BCKGRD METER/RANGE/PPM	.5/ 1/ .13	.3/ 1/ .08	.1/ 1/ .03
DILUTION FACTOR	20.89	32.66	23.74
HC CONCENTRATION PPM	8.28	8.05	9.19
CO CONCENTRATION PPM	28.55	16.03	16.26
CO2 CONCENTRATION PCT	.5973	.3669	.5207
NOX CONCENTRATION PPM	45.17	33.36	43.47
HC MASS GRAMS	1.230	2.027	1.349
CO MASS GRAMS	8.448	8.044	4.761
CO2 MASS GRAMS	2779.32	2895.32	2397.16
NOX MASS GRAMS	20.057	25.123	19.096
PM MASS MILLIGRAMS	355.1	463.7	350.1
FUEL MASS KG	.893	.931	.770
FUEL ECONOMY MPG (L/100KM)	12.40 (18.97)	12.87 (18.27)	14.38 (16.36)

3-BAG COMPOSITE RESULTS

HC	G/MI	.447
CO	G/MI	1.936
NOX	G/MI	6.004
PM	MG/MI	109.8
FUEL ECONOMY MPG (L/100KM)		13.16 (17.87)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254 BASE T1	DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/10/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .854 O .010 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10103 MILES (16255 KM)	TEST WEIGHT 7500 LBS (3401 KG)	BLOWER C.F. = 96

BAROMETER 29.46 IN HG (748.2 MM HG) DRY BULB TEMPERATURE 70.0°F (21.1°C) NOX HUMIDITY C.F. .924

RELATIVE HUMIDITY 51.8 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	764.7
DRY/WET CORRECTION FACTOR, SAMP/BACK	.980/.987
MEASURED DISTANCE MILES (KM)	10.23 (16.47)
BLOWER FLOW RATE SCFM (SCMM)	1044.4 (29.58)
GAS METER FLOW RATE SCFM (SCMM)	.86 (.02)
TOTAL FLOW SCF (SCM)	13321. (377.3)
HC SAMPLE METER/RANGE/PPM (CONT)	14.8/ 9/ 14.85
HC BCKGRD METER/RANGE/PPM	3.5/ 2/ 3.60
CO SAMPLE METER/RANGE/PPM	20.1/ 12/ 19.32
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	83.6/ 11/ .7734
CO2 BCKGRD METER/RANGE/PCT	7.4/ 11/ .0417
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	70.9/ 9/ 70.88
NOX BCKGRD METER/RANGE/PPM	.4/ 1/ .10
DILUTION FACTOR	17.24
HC CONCENTRATION PPM	11.46
CO CONCENTRATION PPM	18.53
CO2 CONCENTRATION PCT	.7341
NOX CONCENTRATION PPM	70.78
HC MASS GRAMS	2.525
CO MASS GRAMS	8.139
CO2 MASS GRAMS	5070.79
NOX MASS GRAMS	47.203
PM MASS MILLIGRAMS	637.9
FUEL MASS KG	1.627
FUEL ECONOMY MPG (L/100KM)	19.52 (12.05)

1-BAG COMPOSITE RESULTS

HC	G/MI	.247
CO	G/MI	.795
NOX	G/MI	4.612
PM	MG/MI	62.3
FUEL ECONOMY MPG (L/100KM)		19.52 (12.05)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254 BASE T2	DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/11/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .854 O .010 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10113 MILES (16271 KM)	TEST WEIGHT 7500 LBS (3401 KG)	Blower C.F. = .96

BAROMETER 29.24 IN HG (742.6 MM HG) DRY BULB TEMPERATURE 69.0°F (20.6°C) NOX HUMIDITY C.F. .933

RELATIVE HUMIDITY 55.2 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	504.6	867.0	505.4
DRY/WET CORRECTION FACTOR, SAMP/BACK	.980/.986	.982/.986	.981/.986
MEASURED DISTANCE MILES (KM)	3.60 (5.79)	3.87 (6.22)	3.59 (5.78)
BLOWER FLOW RATE SCFM (SCMM)	1039.2 (29.43)	1032.0 (29.23)	1042.7 (29.53)
GAS METER FLOW RATE SCFM (SCMM)	.89 (.03)	.92 (.03)	.91 (.03)
TOTAL FLOW SCF (SCM)	8747. (247.7)	14926. (422.7)	8790. (248.9)
HC SAMPLE METER/RANGE/PPM (CONT)	12.5/ 9/ 12.46	12.1/ 9/ 12.14	13.3/ 9/ 13.31
HC BCKGRD METER/RANGE/PPM	3.5/ 2/ 3.60	3.4/ 2/ 3.49	3.6/ 2/ 3.70
CO SAMPLE METER/RANGE/PPM	32.4/ 12/ 31.23	17.6/ 12/ 16.91	17.6/ 12/ 16.91
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19	.2/ 12/ .19	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	75.4/ 11/ .6546	55.4/ 11/ .4166	68.8/ 11/ .5686
CO2 BCKGRD METER/RANGE/PCT	7.3/ 11/ .0411	7.3/ 11/ .0411	7.3/ 11/ .0411
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	46.2/ 9/ 46.23	33.8/ 9/ 33.82	44.0/ 9/ 43.98
NOX BCKGRD METER/RANGE/PPM	.4/ 1/ .10	.4/ 1/ .10	.4/ 1/ .10
DILUTION FACTOR	20.33	31.93	23.43
HC CONCENTRATION PPM	9.04	8.76	9.77
CO CONCENTRATION PPM	30.10	16.29	16.24
CO2 CONCENTRATION PCT	.6155	.3767	.5292
NOX CONCENTRATION PPM	46.14	33.72	43.89
HC MASS GRAMS	1.308	2.163	1.421
CO MASS GRAMS	8.680	8.016	4.707
CO2 MASS GRAMS	2791.28	2915.40	2412.17
NOX MASS GRAMS	20.402	25.444	19.502
PM MASS MILLIGRAMS	346.2	453.6	355.6
FUEL MASS KG	.897	.938	.774
FUEL ECONOMY MPG (L/100KM)	12.45 (18.90)	12.80 (18.38)	14.38 (16.35)

3-BAG COMPOSITE RESULTS

HC	G/MI	.474
CO	G/MI	1.933
NOX	G/MI	6.074
PM	MG/MI	107.9
FUEL ECONOMY MPG (L/100KM)		13.13 (17.91)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254 BASE T2	DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/11/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .854 O .010 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10135 MILES (16307 KM)	TEST WEIGHT 7500 LBS (3401 KG)	BLOWER C.F. = .96

BAROMETER 29.20 IN HG (741.7 MM HG) DRY BULB TEMPERATURE 71.0°F (21.7°C) NOX HUMIDITY C.F. .939

RELATIVE HUMIDITY 52.6 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	768.0
DRY/WET CORRECTION FACTOR, SAMP/BACK	.979/.986
MEASURED DISTANCE MILES (KM)	10.26 (16.52)
BLOWER FLOW RATE SCFM (SCMM)	1029.5 (29.16)
GAS METER FLOW RATE SCFM (SCMM)	.86 (.02)
TOTAL FLOW SCF (SCM)	13189. (373.5)
HC SAMPLE METER/RANGE/PPM (CONT)	15.0/ 9/ 15.01
HC BCKGRD METER/RANGE/PPM	3.7/ 2/ 3.80
CO SAMPLE METER/RANGE/PPM	20.1/ 12/ 19.32
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	83.9/ 11/ .7781
CO2 BCKGRD METER/RANGE/PCT	7.3/ 11/ .0411
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	71.0/ 9/ 71.02
NOX BCKGRD METER/RANGE/PPM	.4/ 1/ .10
DILUTION FACTOR	17.14
HC CONCENTRATION PPM	11.43
CO CONCENTRATION PPM	18.52
CO2 CONCENTRATION PCT	.7393
NOX CONCENTRATION PPM	70.93
HC MASS GRAMS	2.493
CO MASS GRAMS	8.055
CO2 MASS GRAMS	5055.97
NOX MASS GRAMS	47.548
PM MASS MILLIGRAMS	648.9
FUEL MASS KG	1.622
FUEL ECONOMY MPG (L/100KM)	19.63 (11.98)

1-BAG COMPOSITE RESULTS

HC	G/MI	.243
CO	G/MI	.785
NOX	G/MI	4.632
PM	MG/MI	63.2
FUEL ECONOMY MPG (L/100KM)		19.63 (11.98)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254 | TEST 3254 BASE T3 | DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500 | DATE 1/12/2006 RUN | FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8 | DYNO 7 BAG CART 2 | H .136 C .854 O .010 X .000
TRANSMISSION A4 | ACTUAL ROAD LOAD 27.49 HP (20.51 KW) | FTP
ODOMETER 10145 MILES (16323 KM) | TEST WEIGHT 7500 LBS (3401 KG)

Blower C.F. .96

BAROMETER 29.05 IN HG (737.7 MM HG) DRY BULB TEMPERATURE 71.0°F (21.7°C) NOX HUMIDITY C.F. 1.003
RELATIVE HUMIDITY 64.5 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	504.8	868.2	504.9
DRY/WET CORRECTION FACTOR, SAMP/BACK	.977/.983	.979/.983	.977/.983
MEASURED DISTANCE MILES (KM)	3.60 (5.79)	3.88 (6.24)	3.58 (5.76)
BLOWER FLOW RATE SCFM (SCMM)	1046.4 (29.64)	1039.7 (29.45)	1036.7 (29.36)
GAS METER FLOW RATE SCFM (SCMM)	.88 (.02)	.93 (.03)	.89 (.03)
TOTAL FLOW SCF (SCM)	8811. (249.5)	15058. (426.5)	8731. (247.3)
HC SAMPLE METER/RANGE/PPM (CONT)	13.3/ 9/ 13.33	13.2/ 9/ 13.15	14.0/ 9/ 14.00
HC BCKGRD METER/RANGE/PPM	3.5/ 2/ 3.60	3.5/ 2/ 3.60	3.6/ 2/ 3.70
CO SAMPLE METER/RANGE/PPM	34.1/ 12/ 32.88	18.1/ 12/ 17.39	18.7/ 12/ 17.97
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19	.1/ 12/ .10	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	75.3/ 11/ .6532	55.7/ 11/ .4197	68.9/ 11/ .5699
CO2 BCKGRD METER/RANGE/PCT	7.8/ 11/ .0441	7.7/ 11/ .0435	7.8/ 11/ .0441
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	44.1/ 9/ 44.13	32.4/ 9/ 32.42	42.0/ 9/ 42.01
NOX BCKGRD METER/RANGE/PPM	.2/ 2/ .21	.2/ 2/ .21	.2/ 2/ .21
DILUTION FACTOR	20.36	31.69	23.37
HC CONCENTRATION PPM	9.91	9.67	10.45
CO CONCENTRATION PPM	31.60	16.80	17.22
CO2 CONCENTRATION PCT	.6113	.3776	.5277
NOX CONCENTRATION PPM	43.93	32.22	41.82
HC MASS GRAMS	1.445	2.409	1.510
CO MASS GRAMS	9.181	8.339	4.956
CO2 MASS GRAMS	2792.88	2947.95	2388.88
NOX MASS GRAMS	21.022	26.349	19.827
PM MASS MILLIGRAMS	401.9	437.4	382.8
FUEL MASS KG	.898	.948	.767
FUEL ECONOMY MPG (L/100KM)	12.43 (18.92)	12.69 (18.54)	14.48 (16.25)

3-BAG COMPOSITE RESULTS

HC	G/MI	.521
CO	G/MI	2.023
NOX	G/MI	6.251
PM	MG/MI	110.9
FUEL ECONOMY MPG (L/100KM)		13.09 (17.97)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254 BASE T3	DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/12/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .854 O .010 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10168 MILES (16360 KM)	TEST WEIGHT 7500 LBS (3401 KG)	Blower C.F. = .96

BAROMETER 29.04 IN HG (737.6 MM HG) DRY BULB TEMPERATURE 74.0°F (23.3°C) NOX HUMIDITY C.F. .979
RELATIVE HUMIDITY 54.5 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	771.8
DRY/WET CORRECTION FACTOR, SAMP/BACK	.977/.984
MEASURED DISTANCE MILES (KM)	10.24 (16.47)
BLOWER FLOW RATE SCFM (SCMM)	1024.8 (29.02)
GAS METER FLOW RATE SCFM (SCMM)	.79 (.02)
TOTAL FLOW SCF (SCM)	13193. (373.6)
HC SAMPLE METER/RANGE/PPM (CONT)	15.4/ 9/ 15.43
HC BCKGRD METER/RANGE/PPM	3.8/ 2/ 3.91
CO SAMPLE METER/RANGE/PPM	20.2/ 12/ 19.42
CO BCKGRD METER/RANGE/PPM	.1/ 12/ .10
CO2 SAMPLE METER/RANGE/PCT	84.5/ 11/ .7874
CO2 BCKGRD METER/RANGE/PCT	7.9/ 11/ .0447
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	69.6/ 9/ 69.58
NOX BCKGRD METER/RANGE/PPM	.3/ 2/ .31
DILUTION FACTOR	16.94
HC CONCENTRATION PPM	11.75
CO CONCENTRATION PPM	18.69
CO2 CONCENTRATION PCT	.7454
NOX CONCENTRATION PPM	69.29
HC MASS GRAMS	2.565
CO MASS GRAMS	8.130
CO2 MASS GRAMS	5098.82
NOX MASS GRAMS	48.490
PM MASS MILLIGRAMS	745.6
FUEL MASS KG	1.636
FUEL ECONOMY MPG (L/100KM)	19.42 (12.11)

1-BAG COMPOSITE RESULTS

HC	G/MI	.251
CO	G/MI	.794
NOX	G/MI	4.736
PM	MG/MI	72.8
FUEL ECONOMY MPG (L/100KM)		19.42 (12.11)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254 BASE T4	DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/13/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .854 O .010 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10178 MILES (16376 KM)	TEST WEIGHT 7500 LBS (3401 KG)	Blower C.F. .96

BAROMETER 29.37 IN HG (745.9 MM HG) DRY BULB TEMPERATURE 71.0°F (21.7°C) NOX HUMIDITY C.F. .956

RELATIVE HUMIDITY 56.4 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	504.1	867.3	505.3
DRY/WET CORRECTION FACTOR, SAMP/BACK	.979/.985	.981/.985	.980/.985
MEASURED DISTANCE MILES (KM)	3.61 (5.81)	3.85 (6.19)	3.59 (5.77)
BLOWER FLOW RATE SCFM (SCMM)	1062.5 (30.09)	1054.5 (29.87)	1045.8 (29.62)
GAS METER FLOW RATE SCFM (SCMM)	.90 (.03)	.92 (.03)	.88 (.02)
TOTAL FLOW SCF (SCM)	8934. (253.0)	15257. (432.1)	8815. (249.6)
HC SAMPLE METER/RANGE/PPM (CONT)	13.0/ 9/ 13.03	12.6/ 9/ 12.58	13.5/ 9/ 13.45
HC BCKGRD METER/RANGE/PPM	4.0/ 2/ 4.11	4.1/ 2/ 4.21	3.9/ 2/ 4.01
CO SAMPLE METER/RANGE/PPM	32.8/ 12/ 31.62	17.4/ 12/ 16.72	18.2/ 12/ 17.49
CO BCKGRD METER/RANGE/PPM	.0/ 12/ .00	.2/ 12/ .19	.1/ 12/ .10
CO2 SAMPLE METER/RANGE/PCT	74.9/ 11/ .6478	54.5/ 11/ .4073	68.0/ 11/ .5587
CO2 BCKGRD METER/RANGE/PCT	7.4/ 11/ .0417	7.3/ 11/ .0411	7.4/ 11/ .0417
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	45.2/ 9/ 45.21	32.5/ 9/ 32.53	42.7/ 9/ 42.75
NOX BCKGRD METER/RANGE/PPM	.6/ 1/ .15	.9/ 1/ .23	.4/ 1/ .10
DILUTION FACTOR	20.54	32.65	23.84
HC CONCENTRATION PPM	9.12	8.50	9.61
CO CONCENTRATION PPM	30.65	16.10	16.89
CO2 CONCENTRATION PCT	.6081	.3674	.5188
NOX CONCENTRATION PPM	45.06	32.31	42.65
HC MASS GRAMS	1.349	2.145	1.402
CO MASS GRAMS	9.027	8.097	4.909
CO2 MASS GRAMS	2816.82	2906.58	2371.10
NOX MASS GRAMS	20.839	25.520	19.462
PM MASS MILLIGRAMS	413.1	492.3	400.2
FUEL MASS KG	.906	.935	.761
FUEL ECONOMY MPG (L/100KM)	12.37 (19.02)	12.77 (18.43)	14.61 (16.11)

3-BAG COMPOSITE RESULTS

HC	G/MI	.473
CO	G/MI	1.985
NOX	G/MI	6.123
PM	MG/MI	120.6
FUEL ECONOMY MPG (L/100KM)		13.15 (17.88)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254 BASE T4A	DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/14/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .854 O .010 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10243 MILES (16480 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.49 IN HG (749.0 MM HG) DRY BULB TEMPERATURE 70.0°F (21.1°C) NOX HUMIDITY C.F. .924
RELATIVE HUMIDITY 51.8 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	764.9
DRY/WET CORRECTION FACTOR, SAMP/BACK	.979/.987
MEASURED DISTANCE MILES (KM)	10.25 (16.49)
BLOWER FLOW RATE SCFM (SCMM)	1046.5 (29.64)
GAS METER FLOW RATE SCFM (SCMM)	.86 (.02)
TOTAL FLOW SCF (SCM)	13352. (378.1)
HC SAMPLE METER/RANGE/PPM (CONT)	15.5/ 9/ 15.52
HC BCKGRD METER/RANGE/PPM	4.4/ 2/ 4.52
CO SAMPLE METER/RANGE/PPM	20.3/ 12/ 19.52
CO BCKGRD METER/RANGE/PPM	.6/ 12/ .57
CO2 SAMPLE METER/RANGE/PCT	84.5/ 11/ .7874
CO2 BCKGRD METER/RANGE/PCT	7.9/ 11/ .0447
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	69.9/ 9/ 69.94
NOX BCKGRD METER/RANGE/PPM	1.3/ 1/ .33
DILUTION FACTOR	16.94
HC CONCENTRATION PPM	11.26
CO CONCENTRATION PPM	18.36
CO2 CONCENTRATION PCT	.7454
NOX CONCENTRATION PPM	69.63
HC MASS GRAMS	2.487
CO MASS GRAMS	8.082
CO2 MASS GRAMS	5160.30
NOX MASS GRAMS	46.527
PM MASS MILLIGRAMS	728.3
FUEL MASS KG	1.655
FUEL ECONOMY MPG (L/100KM)	19.21 (12.25)

1-BAG COMPOSITE RESULTS

HC	G/MI	.243
CO	G/MI	.788
NOX	G/MI	4.539
PM	MG/MI	71.1
FUEL ECONOMY MPG (L/100KM)		19.21 (12.25)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254 BASE T5	DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/14/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .854 O .010 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10211 MILES (16429 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.46 IN HG (748.2 MM HG) DRY BULB TEMPERATURE 71.0°F (21.7°C) NOX HUMIDITY C.F. .918

RELATIVE HUMIDITY 48.6 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.0	867.1	505.3
DRY/WET CORRECTION FACTOR, SAMP/BACK	.981/.987	.983/.987	.982/.987
MEASURED DISTANCE MILES (KM)	3.60 (5.79)	3.86 (6.22)	3.58 (5.76)
BLOWER FLOW RATE SCFM (SCMM)	1061.2 (30.05)	1049.4 (29.72)	1049.4 (29.72)
GAS METER FLOW RATE SCFM (SCMM)	.87 (.02)	.93 (.03)	.87 (.02)
TOTAL FLOW SCF (SCM)	8939. (253.2)	15178. (429.9)	8845. (250.5)
HC SAMPLE METER/RANGE/PPM (CONT)	12.9/ 9/ 12.94	12.6/ 9/ 12.64	13.4/ 9/ 13.44
HC BCKGRD METER/RANGE/PPM	3.9/ 2/ 4.01	3.9/ 2/ 4.01	4.0/ 2/ 4.11
CO SAMPLE METER/RANGE/PPM	32.9/ 12/ 31.72	17.8/ 12/ 17.10	17.9/ 12/ 17.20
CO BCKGRD METER/RANGE/PPM	.8/ 12/ .77	.9/ 12/ .86	.9/ 12/ .86
CO2 SAMPLE METER/RANGE/PCT	74.8/ 11/ .6464	55.7/ 11/ .4197	69.0/ 11/ .5711
CO2 BCKGRD METER/RANGE/PCT	7.8/ 11/ .0441	8.0/ 11/ .0452	7.6/ 11/ .0429
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	45.6/ 9/ 45.61	33.5/ 9/ 33.53	43.3/ 9/ 43.32
NOX BCKGRD METER/RANGE/PPM	.9/ 1/ .23	.9/ 1/ .23	.8/ 1/ .20
DILUTION FACTOR	20.58	31.69	23.33
HC CONCENTRATION PPM	9.12	8.76	9.50
CO CONCENTRATION PPM	30.10	15.87	15.93
CO2 CONCENTRATION PCT	.6045	.3759	.5301
NOX CONCENTRATION PPM	45.40	33.31	43.13
HC MASS GRAMS	1.349	2.199	1.390
CO MASS GRAMS	8.872	7.943	4.644
CO2 MASS GRAMS	2801.88	2958.03	2430.81
NOX MASS GRAMS	20.171	25.129	18.960
PM MASS MILLIGRAMS	401.3	488.4	414.6
FUEL MASS KG	.901	.951	.780
FUEL ECONOMY MPG (L/100KM)	12.38 (19.00)	12.60 (18.67)	14.22 (16.54)

3-BAG COMPOSITE RESULTS

HC	G/MI	.479
CO	G/MI	1.934
NOX	G/MI	5.989
PM	MG/MI	120.5
FUEL ECONOMY MPG (L/100KM)		12.97 (18.14)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254 BASE T5	DIESEL 27125-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/14/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .854 O .010 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10233 MILES (16464 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.48 IN HG (748.8 MM HG) DRY BULB TEMPERATURE 71.0°F (21.7°C) NOX HUMIDITY C.F. .935

RELATIVE HUMIDITY 52.4 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	765.3
DRY/WET CORRECTION FACTOR, SAMP/BACK	.979/.986
MEASURED DISTANCE MILES (KM)	10.26 (16.50)
BLOWER FLOW RATE SCFM (SCMM)	1044.2 (29.57)
GAS METER FLOW RATE SCFM (SCMM)	.88 (.02)
TOTAL FLOW SCF (SCM)	13331. (377.5)
HC SAMPLE METER/RANGE/PPM (CONT)	15.2/ 9/ 15.23
HC BCKGRD METER/RANGE/PPM	4.1/ 2/ 4.21
CO SAMPLE METER/RANGE/PPM	20.2/ 12/ 19.42
CO BCKGRD METER/RANGE/PPM	1.0/ 12/ .96
CO2 SAMPLE METER/RANGE/PCT	83.9/ 11/ .7781
CO2 BCKGRD METER/RANGE/PCT	7.8/ 11/ .0441
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	69.5/ 9/ 69.48
NOX BCKGRD METER/RANGE/PPM	1.3/ 1/ .33
DILUTION FACTOR	17.14
HC CONCENTRATION PPM	11.26
CO CONCENTRATION PPM	17.91
CO2 CONCENTRATION PCT	.7366
NOX CONCENTRATION PPM	69.18
HC MASS GRAMS	2.484
CO MASS GRAMS	7.871
CO2 MASS GRAMS	5091.13
NOX MASS GRAMS	46.716
PM MASS MILLIGRAMS	738.1
FUEL MASS KG	1.633
FUEL ECONOMY MPG (L/100KM)	19.49 (12.07)

1-BAG COMPOSITE RESULTS

HC	G/MI	.242
CO	G/MI	.767
NOX	G/MI	4.555
PM	MG/MI	72.0
FUEL ECONOMY MPG (L/100KM)		19.49 (12.07)

APPENDIX G

ADDITIZED FUEL TEST PRINTOUTS

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT1	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/18/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10286 MILES (16550 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.33 IN HG (745.0 MM HG) DRY BULB TEMPERATURE 71.0°F (21.7°C) NOX HUMIDITY C.F. .956

RELATIVE HUMIDITY 56.4 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	504.9	867.4	504.7
DRY/WET CORRECTION FACTOR, SAMP/BACK	.979/.985	.981/.985	.980/.985
MEASURED DISTANCE MILES (KM)	3.59 (5.77)	3.84 (6.17)	3.58 (5.76)
BLOWER FLOW RATE SCFM (SCMM)	1054.5 (29.86)	1043.3 (29.55)	1054.1 (29.85)
GAS METER FLOW RATE SCFM (SCMM)	.87 (.02)	.92 (.03)	.87 (.02)
TOTAL FLOW SCF (SCM)	8881. (251.5)	15096. (427.5)	8874. (251.3)
HC SAMPLE METER/RANGE/PPM (CONT)	13.5/ 9/ 13.49	13.3/ 9/ 13.34	14.4/ 9/ 14.36
HC BCKGRD METER/RANGE/PPM	3.6/ 2/ 3.70	3.6/ 2/ 3.70	3.6/ 2/ 3.70
CO SAMPLE METER/RANGE/PPM	35.7/ 12/ 34.44	19.3/ 12/ 18.55	18.9/ 12/ 18.16
CO BCKGRD METER/RANGE/PPM	.3/ 12/ .29	.3/ 12/ .29	.3/ 12/ .29
CO2 SAMPLE METER/RANGE/PCT	74.1/ 11/ .6370	54.6/ 11/ .4083	68.4/ 11/ .5637
CO2 BCKGRD METER/RANGE/PCT	7.8/ 11/ .0441	7.6/ 11/ .0429	7.7/ 11/ .0435
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	45.2/ 9/ 45.21	33.0/ 9/ 32.97	43.4/ 9/ 43.42
NOX BCKGRD METER/RANGE/PPM	.6/ 1/ .15	.6/ 1/ .15	.4/ 1/ .10
DILUTION FACTOR	20.83	32.49	23.58
HC CONCENTRATION PPM	9.97	9.76	10.81
CO CONCENTRATION PPM	33.12	17.79	17.36
CO2 CONCENTRATION PCT	.5950	.3668	.5220
NOX CONCENTRATION PPM	45.06	32.83	43.32
HC MASS GRAMS	1.470	2.445	1.593
CO MASS GRAMS	9.697	8.855	5.080
CO2 MASS GRAMS	2740.13	2870.70	2402.02
NOX MASS GRAMS	20.727	25.664	19.910
PM MASS MILLIGRAMS	371.6	435.2	363.6
FUEL MASS KG	.885	.927	.774
FUEL ECONOMY MPG (L/100KM)	12.57 (18.71)	12.83 (18.34)	14.34 (16.41)

3-BAG COMPOSITE RESULTS

HC	G/MI	.537
CO	G/MI	2.146
NOX	G/MI	6.191
PM	MG/MI	108.2
FUEL ECONOMY MPG (L/100KM)		13.17 (17.87)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT1	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/18/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10308 MILES (16585 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.29 IN HG (744.1 MM HG) DRY BULB TEMPERATURE 72.0°F (22.2°C) NOX HUMIDITY C.F. .931
RELATIVE HUMIDITY 49.4 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	765.7
DRY/WET CORRECTION FACTOR, SAMP/BACK	.979/.987
MEASURED DISTANCE MILES (KM)	10.26 (16.51)
BLOWER FLOW RATE SCFM (SCMM)	1031.1 (29.20)
GAS METER FLOW RATE SCFM (SCMM)	.86 (.02)
TOTAL FLOW SCF (SCM)	13169. (373.0)
HC SAMPLE METER/RANGE/PPM (CONT)	15.7/ 9/ 15.71
HC BCKGRD METER/RANGE/PPM	3.4/ 2/ 3.49
CO SAMPLE METER/RANGE/PPM	20.6/ 12/ 19.80
CO BCKGRD METER/RANGE/PPM	.3/ 12/ .29
CO2 SAMPLE METER/RANGE/PCT	83.2/ 11/ .7673
CO2 BCKGRD METER/RANGE/PCT	7.5/ 11/ .0423
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	70.1/ 9/ 70.14
NOX BCKGRD METER/RANGE/PPM	.5/ 1/ .13
DILUTION FACTOR	17.34
HC CONCENTRATION PPM	12.42
CO CONCENTRATION PPM	18.93
CO2 CONCENTRATION PCT	.7274
NOX CONCENTRATION PPM	70.02
HC MASS GRAMS	2.716
CO MASS GRAMS	8.218
CO2 MASS GRAMS	4967.18
NOX MASS GRAMS	46.475
PM MASS MILLIGRAMS	509.0
FUEL MASS KG	1.600
FUEL ECONOMY MPG (L/100KM)	19.90 (11.82)

1-BAG COMPOSITE RESULTS

HC	G/MI	.265
CO	G/MI	.801
NOX	G/MI	4.530
PM	MG/MI	49.6
FUEL ECONOMY MPG (L/100KM)		19.90 (11.82)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT4	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/21/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10383 MILES (16706 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.36 IN HG (745.7 MM HG) DRY BULB TEMPERATURE 72.0°F (22.2°C) NOX HUMIDITY C.F. .912

RELATIVE HUMIDITY 45.7 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.0	866.6	505.0
DRY/WET CORRECTION FACTOR, SAMP/BACK	.982/.988	.984/.988	.982/.988
MEASURED DISTANCE MILES (KM)	3.58 (5.76)	3.85 (6.19)	3.58 (5.76)
BLOWER FLOW RATE SCFM (SCMM)	1050.7 (29.76)	1040.9 (29.48)	1045.5 (29.61)
GAS METER FLOW RATE SCFM (SCMM)	.89 (.03)	.93 (.03)	.90 (.03)
TOTAL FLOW SCF (SCM)	8851. (250.7)	15047. (426.1)	8807. (249.4)
HC SAMPLE METER/RANGE/PPM (CONT)	13.5/ 9/ 13.48	13.4/ 9/ 13.38	14.2/ 9/ 14.25
HC BCKGRD METER/RANGE/PPM	3.9/ 2/ 4.01	3.8/ 2/ 3.91	4.0/ 2/ 4.11
CO SAMPLE METER/RANGE/PPM	32.6/ 12/ 31.43	18.2/ 12/ 17.49	18.3/ 12/ 17.58
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19	.0/ 12/ .00	.3/ 12/ .29
CO2 SAMPLE METER/RANGE/PCT	73.0/ 11/ .6224	54.3/ 11/ .4053	68.5/ 11/ .5649
CO2 BCKGRD METER/RANGE/PCT	7.3/ 11/ .0411	7.3/ 11/ .0411	7.2/ 11/ .0405
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	45.8/ 9/ 45.84	33.4/ 9/ 33.40	44.6/ 9/ 44.60
NOX BCKGRD METER/RANGE/PPM	.2/ 1/ .05	.3/ 1/ .08	.4/ 1/ .10
DILUTION FACTOR	21.33	32.74	23.54
HC CONCENTRATION PPM	9.66	9.59	10.31
CO CONCENTRATION PPM	30.40	17.09	16.86
CO2 CONCENTRATION PCT	.5832	.3654	.5261
NOX CONCENTRATION PPM	45.79	33.33	44.50
HC MASS GRAMS	1.419	2.397	1.508
CO MASS GRAMS	8.872	8.479	4.896
CO2 MASS GRAMS	2676.36	2850.70	2402.30
NOX MASS GRAMS	20.023	24.772	19.360
PM MASS MILLIGRAMS	353.4	429.2	382.8
FUEL MASS KG	.864	.921	.774
FUEL ECONOMY MPG (L/100KM)	12.86 (18.29)	12.97 (18.14)	14.35 (16.39)

3-BAG COMPOSITE RESULTS

HC	G/MI	.520
CO	G/MI	2.030
NOX	G/MI	5.978
PM	MG/MI	107.6
FUEL ECONOMY MPG (L/100KM)		13.30 (17.68)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT4	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/21/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10405 MILES (16741 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.37 IN HG (746.1 MM HG) DRY BULB TEMPERATURE 71.0°F (21.7°C) NOX HUMIDITY C.F. .919
RELATIVE HUMIDITY 48.7 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	764.9
DRY/WET CORRECTION FACTOR, SAMP/BACK	.980/.987
MEASURED DISTANCE MILES (KM)	10.24 (16.48)
BLOWER FLOW RATE SCFM (SCMM)	1031.0 (29.20)
GAS METER FLOW RATE SCFM (SCMM)	.87 (.02)
TOTAL FLOW SCF (SCM)	13154. (372.5)
HC SAMPLE METER/RANGE/PPM (CONT)	16.0/ 9/ 15.98
HC BCKGRD METER/RANGE/PPM	4.4/ 2/ 4.52
CO SAMPLE METER/RANGE/PPM	19.8/ 12/ 19.03
CO BCKGRD METER/RANGE/PPM	.0/ 12/ .00
CO2 SAMPLE METER/RANGE/PCT	83.6/ 11/ .7734
CO2 BCKGRD METER/RANGE/PCT	7.4/ 11/ .0417
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	71.6/ 9/ 71.63
NOX BCKGRD METER/RANGE/PPM	.4/ 1/ .10
DILUTION FACTOR	17.21
HC CONCENTRATION PPM	11.72
CO CONCENTRATION PPM	18.45
CO2 CONCENTRATION PCT	.7342
NOX CONCENTRATION PPM	71.53
HC MASS GRAMS	2.559
CO MASS GRAMS	8.000
CO2 MASS GRAMS	5007.34
NOX MASS GRAMS	46.811
PM MASS MILLIGRAMS	705.0
FUEL MASS KG	1.612
FUEL ECONOMY MPG (L/100KM)	19.70 (11.94)

1-BAG COMPOSITE RESULTS

HC	G/MI	.250
CO	G/MI	.781
NOX	G/MI	4.571
PM	MG/MI	68.8
FUEL ECONOMY MPG (L/100KM)		19.70 (11.94)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT5	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/22/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10416 MILES (16759 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.20 IN HG (741.8 MM HG) DRY BULB TEMPERATURE 73.0°F (22.8°C) NOX HUMIDITY C.F. .985

RELATIVE HUMIDITY 57.6 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	504.7	866.3	504.8
DRY/WET CORRECTION FACTOR, SAMP/BACK	.978/.984	.980/.984	.978/.984
MEASURED DISTANCE MILES (KM)	3.58 (5.76)	3.86 (6.21)	3.56 (5.73)
BLOWER FLOW RATE SCFM (SCMM)	1042.0 (29.51)	1034.8 (29.31)	1037.2 (29.37)
GAS METER FLOW RATE SCFM (SCMM)	.88 (.02)	.92 (.03)	.87 (.02)
TOTAL FLOW SCF (SCM)	8773. (248.4)	14954. (423.5)	8734. (247.3)
HC SAMPLE METER/RANGE/PPM (CONT)	13.8/ 9/ 13.82	13.6/ 9/ 13.64	14.5/ 9/ 14.53
HC BCKGRD METER/RANGE/PPM	3.8/ 2/ 3.91	3.8/ 2/ 3.91	3.7/ 2/ 3.80
CO SAMPLE METER/RANGE/PPM	35.2/ 12/ 33.95	19.0/ 12/ 18.26	18.9/ 12/ 18.16
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19	.2/ 12/ .19	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	74.8/ 11/ .6464	54.6/ 11/ .4083	68.4/ 11/ .5637
CO2 BCKGRD METER/RANGE/PCT	7.4/ 11/ .0417	7.4/ 11/ .0417	7.3/ 11/ .0411
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	45.1/ 9/ 45.12	32.9/ 9/ 32.91	42.9/ 9/ 42.94
NOX BCKGRD METER/RANGE/PPM	.4/ 1/ .10	.4/ 1/ .10	.2/ 1/ .05
DILUTION FACTOR	20.53	32.49	23.58
HC CONCENTRATION PPM	10.11	9.85	10.89
CO CONCENTRATION PPM	32.72	17.59	17.45
CO2 CONCENTRATION PCT	.6067	.3679	.5243
NOX CONCENTRATION PPM	45.03	32.81	42.90
HC MASS GRAMS	1.472	2.447	1.579
CO MASS GRAMS	9.462	8.674	5.024
CO2 MASS GRAMS	2759.77	2852.53	2374.15
NOX MASS GRAMS	21.068	26.168	19.981
PM MASS MILLIGRAMS	158.4	445.4	392.4
FUEL MASS KG	.891	.921	.765
FUEL ECONOMY MPG (L/100KM)	12.45 (18.89)	13.00 (18.10)	14.43 (16.30)

3-BAG COMPOSITE RESULTS

HC	G/MI	.536
CO	G/MI	2.100
NOX	G/MI	6.275
PM	MG/MI	99.2
FUEL ECONOMY MPG (L/100KM)		13.25 (17.75)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT5	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/22/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10438 MILES (16794 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.22 IN HG (742.2 MM HG) DRY BULB TEMPERATURE 72.0°F (22.2°C) NOX HUMIDITY C.F. .971
RELATIVE HUMIDITY 57.0 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	765.6
DRY/WET CORRECTION FACTOR, SAMP/BACK	.977/.984
MEASURED DISTANCE MILES (KM)	10.26 (16.50)
BLOWER FLOW RATE SCFM (SCMM)	1034.7 (29.30)
GAS METER FLOW RATE SCFM (SCMM)	.87 (.02)
TOTAL FLOW SCF (SCM)	13214. (374.2)
HC SAMPLE METER/RANGE/PPM (CONT)	16.1/ 9/ 16.11
HC BCKGRD METER/RANGE/PPM	3.5/ 2/ 3.60
CO SAMPLE METER/RANGE/PPM	20.6/ 12/ 19.80
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	84.2/ 11/ .7827
CO2 BCKGRD METER/RANGE/PCT	7.5/ 11/ .0423
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	69.0/ 9/ 69.00
NOX BCKGRD METER/RANGE/PPM	.5/ 1/ .13
DILUTION FACTOR	17.00
HC CONCENTRATION PPM	12.73
CO CONCENTRATION PPM	18.96
CO2 CONCENTRATION PCT	.7429
NOX CONCENTRATION PPM	68.88
HC MASS GRAMS	2.792
CO MASS GRAMS	8.260
CO2 MASS GRAMS	5089.81
NOX MASS GRAMS	47.848
PM MASS MILLIGRAMS	703.6
FUEL MASS KG	1.639
FUEL ECONOMY MPG (L/100KM)	19.41 (12.12)

1-BAG COMPOSITE RESULTS

HC	G/MI	.272
CO	G/MI	.805
NOX	G/MI	4.665
PM	MG/MI	68.6
FUEL ECONOMY MPG (L/100KM)		19.41 (12.12)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT6	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/23/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10448 MILES (16810 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.33 IN HG (745.0 MM HG) DRY BULB TEMPERATURE 71.0°F (21.7°C) NOX HUMIDITY C.F. .956

RELATIVE HUMIDITY 56.4 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.0	866.9	505.7
DRY/WET CORRECTION FACTOR, SAMP/BACK	.979/.985	.981/.985	.980/.985
MEASURED DISTANCE MILES (KM)	3.60 (5.79)	3.87 (6.23)	3.57 (5.74)
BLOWER FLOW RATE SCFM (SCMM)	1062.0 (30.08)	1046.0 (29.62)	1038.4 (29.41)
GAS METER FLOW RATE SCFM (SCMM)	.89 (.03)	.93 (.03)	.87 (.02)
TOTAL FLOW SCF (SCM)	8946. (253.3)	15127. (428.4)	8759. (248.1)
HC SAMPLE METER/RANGE/PPM (CONT)	13.9/ 9/ 13.91	13.5/ 9/ 13.46	14.4/ 9/ 14.43
HC BCKGRD METER/RANGE/PPM	4.0/ 2/ 4.11	4.0/ 2/ 4.11	3.8/ 2/ 3.91
CO SAMPLE METER/RANGE/PPM	33.5/ 12/ 32.30	18.2/ 12/ 17.49	18.1/ 12/ 17.39
CO BCKGRD METER/RANGE/PPM	.3/ 12/ .29	.3/ 12/ .29	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	74.5/ 11/ .6424	54.5/ 11/ .4073	68.1/ 11/ .5600
CO2 BCKGRD METER/RANGE/PCT	7.5/ 11/ .0423	7.7/ 11/ .0435	7.6/ 11/ .0429
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	45.1/ 9/ 45.08	33.0/ 9/ 33.01	42.6/ 9/ 42.58
NOX BCKGRD METER/RANGE/PPM	.2/ 1/ .05	.4/ 1/ .10	.3/ 1/ .08
DILUTION FACTOR	20.67	32.58	23.74
HC CONCENTRATION PPM	10.00	9.47	10.69
CO CONCENTRATION PPM	31.04	16.76	16.71
CO2 CONCENTRATION PCT	.6021	.3652	.5189
NOX CONCENTRATION PPM	45.03	32.91	42.51
HC MASS GRAMS	1.486	2.380	1.554
CO MASS GRAMS	9.155	8.358	4.824
CO2 MASS GRAMS	2792.85	2864.06	2356.58
NOX MASS GRAMS	20.862	25.784	19.283
PM MASS MILLIGRAMS	356.0	433.6	386.2
FUEL MASS KG	.902	.925	.760
FUEL ECONOMY MPG (L/100KM)	12.38 (19.00)	12.99 (18.11)	14.58 (16.13)

3-BAG COMPOSITE RESULTS

HC	G/MI	.524
CO	G/MI	2.017
NOX	G/MI	6.136
PM	MG/MI	108.2
FUEL ECONOMY MPG (L/100KM)		13.27 (17.73)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT6	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/23/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10470 MILES (16846 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.36 IN HG (745.7 MM HG) DRY BULB TEMPERATURE 72.0°F (22.2°C) NOX HUMIDITY C.F. .949
RELATIVE HUMIDITY 53.1 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	764.9
DRY/WET CORRECTION FACTOR, SAMP/BACK	.978/.986
MEASURED DISTANCE MILES (KM)	10.26 (16.51)
BLOWER FLOW RATE SCFM (SCMM)	1037.8 (29.39)
GAS METER FLOW RATE SCFM (SCMM)	.87 (.02)
TOTAL FLOW SCF (SCM)	13242. (375.0)
HC SAMPLE METER/RANGE/PPM (CONT)	16.0/ 9/ 16.04
HC BCKGRD METER/RANGE/PPM	3.8/ 2/ 3.91
CO SAMPLE METER/RANGE/PPM	20.4/ 12/ 19.61
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	83.6/ 11/ .7734
CO2 BCKGRD METER/RANGE/PCT	7.5/ 11/ .0423
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	69.6/ 9/ 69.64
NOX BCKGRD METER/RANGE/PPM	.4/ 1/ .10
DILUTION FACTOR	17.21
HC CONCENTRATION PPM	12.36
CO CONCENTRATION PPM	18.80
CO2 CONCENTRATION PCT	.7336
NOX CONCENTRATION PPM	69.55
HC MASS GRAMS	2.717
CO MASS GRAMS	8.209
CO2 MASS GRAMS	5036.83
NOX MASS GRAMS	47.321
PM MASS MILLIGRAMS	715.9
FUEL MASS KG	1.622
FUEL ECONOMY MPG (L/100KM)	19.62 (11.99)

1-BAG COMPOSITE RESULTS

HC	G/MI	.265
CO	G/MI	.800
NOX	G/MI	4.612
PM	MG/MI	69.8
FUEL ECONOMY MPG (L/100KM)		19.62 (11.99)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT7	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/24/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10481 MILES (16863 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.37 IN HG (746.0 MM HG) DRY BULB TEMPERATURE 73.0°F (22.8°C) NOX HUMIDITY C.F. .942

RELATIVE HUMIDITY 50.0 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.0	866.8	504.9
DRY/WET CORRECTION FACTOR, SAMP/BACK	.980/.986	.982/.986	.981/.986
MEASURED DISTANCE MILES (KM)	3.59 (5.77)	3.86 (6.21)	3.57 (5.75)
BLOWER FLOW RATE SCFM (SCMM)	1046.7 (29.64)	1033.4 (29.27)	1035.4 (29.32)
GAS METER FLOW RATE SCFM (SCMM)	.89 (.03)	.92 (.03)	.88 (.02)
TOTAL FLOW SCF (SCM)	8817. (249.7)	14943. (423.2)	8720. (247.0)
HC SAMPLE METER/RANGE/PPM (CONT)	13.9/ 9/ 13.92	13.5/ 9/ 13.48	14.5/ 9/ 14.46
HC BCKGRD METER/RANGE/PPM	3.6/ 2/ 3.70	3.6/ 2/ 3.70	3.6/ 2/ 3.70
CO SAMPLE METER/RANGE/PPM	35.8/ 12/ 34.54	18.9/ 12/ 18.16	19.1/ 12/ 18.36
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19	.2/ 12/ .19	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	74.0/ 11/ .6357	54.6/ 11/ .4083	67.6/ 11/ .5538
CO2 BCKGRD METER/RANGE/PCT	7.6/ 11/ .0429	7.5/ 11/ .0423	7.3/ 11/ .0411
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	44.9/ 9/ 44.93	33.4/ 9/ 33.40	33.4/ 9/ 33.40
NOX BCKGRD METER/RANGE/PPM	.3/ 1/ .08	.3/ 1/ .08	.3/ 1/ .08
DILUTION FACTOR	20.88	32.49	24.00
HC CONCENTRATION PPM	10.40	9.89	10.91
CO CONCENTRATION PPM	33.37	17.54	17.68
CO2 CONCENTRATION PCT	.5948	.3673	.5144
NOX CONCENTRATION PPM	44.85	33.33	33.33
HC MASS GRAMS	1.522	2.454	1.580
CO MASS GRAMS	9.701	8.643	5.083
CO2 MASS GRAMS	2719.33	2846.01	2325.83
NOX MASS GRAMS	20.168	25.398	14.822
PM MASS MILLIGRAMS	590.0	462.0	554.4
FUEL MASS KG	.878	.919	.750
FUEL ECONOMY MPG (L/100KM)	12.68 (18.56)	13.03 (18.05)	14.78 (15.91)

3-BAG COMPOSITE RESULTS

HC	G/MI	.539
CO	G/MI	2.111
NOX	G/MI	5.713
PM	MG/MI	138.6
FUEL ECONOMY MPG (L/100KM)		13.41 (17.55)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT7	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/24/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10503 MILES (16899 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.35 IN HG (745.6 MM HG) DRY BULB TEMPERATURE 73.0°F (22.8°C) NOX HUMIDITY C.F. .962
RELATIVE HUMIDITY 53.7 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	764.9
DRY/WET CORRECTION FACTOR, SAMP/BACK	.977/.985
MEASURED DISTANCE MILES (KM)	10.25 (16.50)
BLOWER FLOW RATE SCFM (SCMM)	1024.2 (29.01)
GAS METER FLOW RATE SCFM (SCMM)	.87 (.02)
TOTAL FLOW SCF (SCM)	13068. (370.1)
HC SAMPLE METER/RANGE/PPM (CONT)	15.8/ 9/ 15.85
HC BCKGRD METER/RANGE/PPM	3.4/ 2/ 3.49
CO SAMPLE METER/RANGE/PPM	20.8/ 12/ 20.00
CO BCKGRD METER/RANGE/PPM	.2/ 12/ .19
CO2 SAMPLE METER/RANGE/PCT	83.9/ 11/ .7781
CO2 BCKGRD METER/RANGE/PCT	7.5/ 11/ .0423
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	69.7/ 9/ 69.68
NOX BCKGRD METER/RANGE/PPM	.4/ 1/ .10
DILUTION FACTOR	17.10
HC CONCENTRATION PPM	12.56
CO CONCENTRATION PPM	19.17
CO2 CONCENTRATION PCT	.7382
NOX CONCENTRATION PPM	69.59
HC MASS GRAMS	2.725
CO MASS GRAMS	8.259
CO2 MASS GRAMS	5002.06
NOX MASS GRAMS	47.356
PM MASS MILLIGRAMS	705.6
FUEL MASS KG	1.611
FUEL ECONOMY MPG (L/100KM)	19.75 (11.91)

1-BAG COMPOSITE RESULTS

HC	G/MI	.266
CO	G/MI	.806
NOX	G/MI	4.619
PM	MG/MI	68.8
FUEL ECONOMY MPG (L/100KM)		19.75 (11.91)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 3-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT8	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/25/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	FTP
ODOMETER 10513 MILES (16915 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.55 IN HG (750.6 MM HG) DRY BULB TEMPERATURE 73.0°F (22.8°C) NOX HUMIDITY C.F. .959

RELATIVE HUMIDITY 53.6 PCT.

BAG NUMBER	1	2	3
BAG DESCRIPTION	COLD TRANSIENT (0-505 SEC.)	STABILIZED (505-1372 SEC.)	HOT TRANSIENT (0- 505 SEC.)
RUN TIME SECONDS	505.1	866.9	504.4
DRY/WET CORRECTION FACTOR, SAMP/BACK	.979/.985	.981/.985	.980/.985
MEASURED DISTANCE MILES (KM)	3.59 (5.77)	3.85 (6.20)	3.56 (5.73)
BLOWER FLOW RATE SCFM (SCMM)	1058.0 (29.96)	1038.1 (29.40)	1034.2 (29.29)
GAS METER FLOW RATE SCFM (SCMM)	.90 (.03)	.93 (.03)	.89 (.03)
TOTAL FLOW SCF (SCM)	8914. (252.5)	15012. (425.1)	8702. (246.4)
HC SAMPLE METER/RANGE/PPM (CONT)	14.0/ 9/ 14.03	13.8/ 9/ 13.83	14.6/ 9/ 14.59
HC BCKGRD METER/RANGE/PPM	3.8/ 2/ 3.91	3.8/ 2/ 3.91	4.1/ 2/ 4.21
CO SAMPLE METER/RANGE/PPM	34.1/ 12/ 32.88	19.3/ 12/ 18.55	19.4/ 12/ 18.65
CO BCKGRD METER/RANGE/PPM	.9/ 12/ .86	.9/ 12/ .86	.9/ 12/ .86
CO2 SAMPLE METER/RANGE/PCT	73.3/ 11/ .6263	54.6/ 11/ .4083	67.2/ 11/ .5490
CO2 BCKGRD METER/RANGE/PCT	8.4/ 11/ .0476	8.5/ 11/ .0482	7.9/ 11/ .0447
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	43.6/ 9/ 43.56	32.2/ 9/ 32.17	42.9/ 9/ 42.92
NOX BCKGRD METER/RANGE/PPM	.6/ 1/ .15	.7/ 1/ .18	.7/ 1/ .18
DILUTION FACTOR	21.19	32.49	24.21
HC CONCENTRATION PPM	10.31	10.05	10.55
CO CONCENTRATION PPM	31.11	17.26	17.31
CO2 CONCENTRATION PCT	.5810	.3616	.5062
NOX CONCENTRATION PPM	43.41	32.00	42.76
HC MASS GRAMS	1.526	2.504	1.524
CO MASS GRAMS	9.142	8.543	4.967
CO2 MASS GRAMS	2685.37	2814.68	2283.67
NOX MASS GRAMS	20.101	24.951	19.325
PM MASS MILLIGRAMS	394.0	463.3	623.7
FUEL MASS KG	.867	.909	.736
FUEL ECONOMY MPG (L/100KM)	12.83 (18.33)	13.15 (17.89)	14.99 (15.69)

3-BAG COMPOSITE RESULTS

HC	G/MI	.543
CO	G/MI	2.061
NOX	G/MI	6.008
PM	MG/MI	133.1
FUEL ECONOMY MPG (L/100KM)		13.55 (17.36)

SOUTHWEST RESEARCH INSTITUTE - DEPARTMENT OF EMISSIONS RESEARCH

COMPUTER PROGRAM LDT 2.9-R 1-BAG EPA FTP VEHICLE EMISSION RESULTS PROJECT NO. 03-03227-20

VEHICLE NUMBER 3254	TEST 3254CANDT8	DIESEL 27132-F
VEHICLE MODEL 6 CHEVY C2500	DATE 1/25/2006 RUN	FUEL DENSITY 6.839 LB/GAL
ENGINE 6.6 L (403 CID)-V8	DYNO 7 BAG CART 2	H .136 C .851 O .013 X .000
TRANSMISSION A4	ACTUAL ROAD LOAD 27.49 HP (20.51 KW)	HFET
ODOMETER 10535 MILES (16950 KM)	TEST WEIGHT 7500 LBS (3401 KG)	

BAROMETER 29.57 IN HG (751.1 MM HG) DRY BULB TEMPERATURE 72.0°F (22.2°C) NOX HUMIDITY C.F. .946
RELATIVE HUMIDITY 53.0 PCT.

BAG NUMBER	1
BAG DESCRIPTION	
RUN TIME SECONDS	765.3
DRY/WET CORRECTION FACTOR, SAMP/BACK	.978/.986
MEASURED DISTANCE MILES (KM)	10.24 (16.48)
BLOWER FLOW RATE SCFM (SCMM)	1029.7 (29.16)
GAS METER FLOW RATE SCFM (SCMM)	.89 (.03)
TOTAL FLOW SCF (SCM)	13146. (372.3)
HC SAMPLE METER/RANGE/PPM (CONT)	16.0/ 9/ 16.02
HC BCKGRD METER/RANGE/PPM	4.1/ 2/ 4.21
CO SAMPLE METER/RANGE/PPM	21.9/ 12/ 21.06
CO BCKGRD METER/RANGE/PPM	1.0/ 12/ .96
CO2 SAMPLE METER/RANGE/PCT	83.0/ 11/ .7642
CO2 BCKGRD METER/RANGE/PCT	8.0/ 11/ .0452
NOX SAMPLE METER/RANGE/PPM (CONT)(D)	68.5/ 9/ 68.49
NOX BCKGRD METER/RANGE/PPM	.6/ 1/ .15
DILUTION FACTOR	17.41
HC CONCENTRATION PPM	12.05
CO CONCENTRATION PPM	19.50
CO2 CONCENTRATION PCT	.7216
NOX CONCENTRATION PPM	68.35
HC MASS GRAMS	2.630
CO MASS GRAMS	8.451
CO2 MASS GRAMS	4918.55
NOX MASS GRAMS	46.046
PM MASS MILLIGRAMS	682.8
FUEL MASS KG	1.584
FUEL ECONOMY MPG (L/100KM)	20.06 (11.73)

1-BAG COMPOSITE RESULTS

HC	G/MI	.257
CO	G/MI	.825
NOX	G/MI	4.495
PM	MG/MI	66.7
FUEL ECONOMY MPG (L/100KM)		20.06 (11.73)